For Editorial Contents see page 625

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TELEGRAM-FORM CONVEYING SYSTEMS; GENERAL POST OFFICE.

COLONEL A. S. ANGWIN, D.S.O., M.C., M.I.E.E., ENGINEER-IN-CHIEF.

(*For Description see page* 615.)

FIG. 57. PNEUMATIC DISTRIBUTION POSITION; INLAND EXCHANGE.

FIG. 58. PNEUMATIC DISTRIBUTION POSITION; OVERSEAS EXCHANGE.

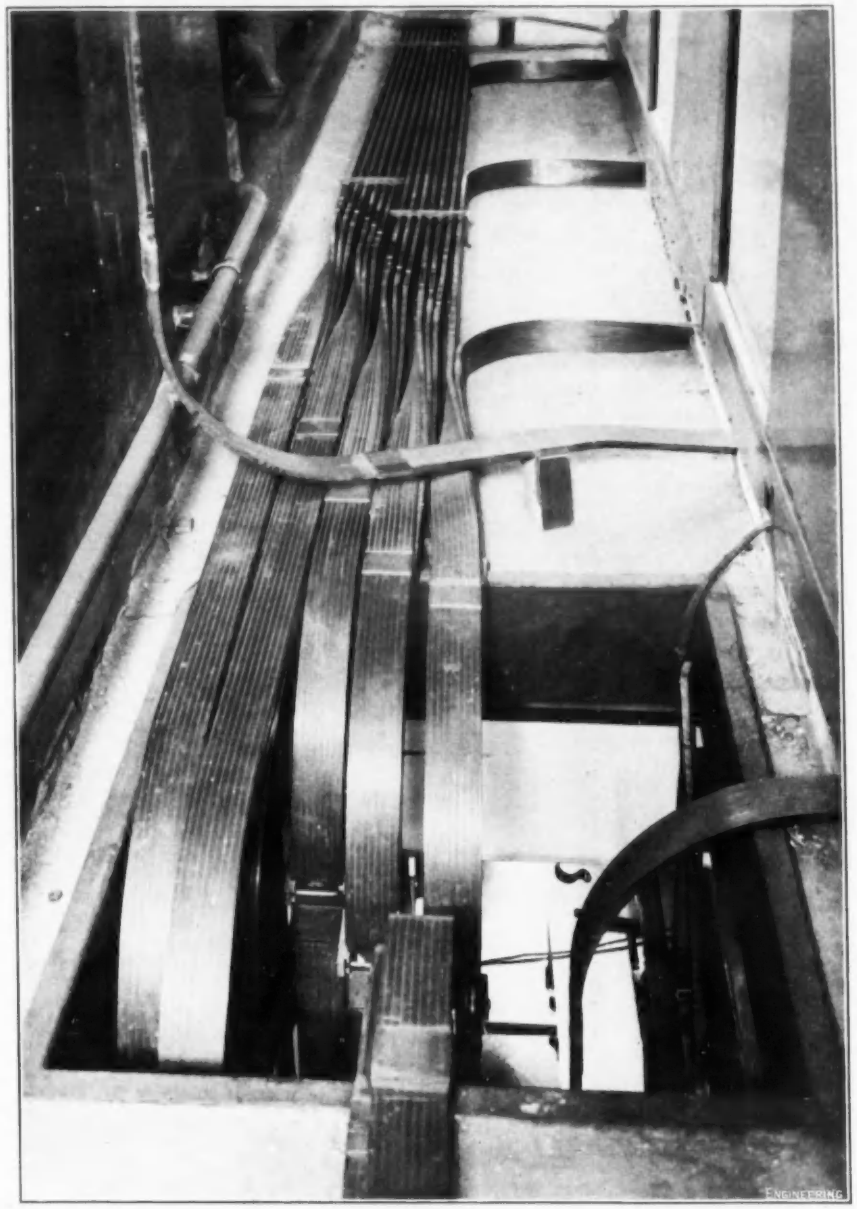


FIG. 59. TELEPHONE-TICKET PNEUMATIC TUBES.

(*To face page* 615.)

TELEGRAM-FORM CONVEYING SYSTEMS; GENERAL POST OFFICE—IV.*

IN the third article of the series dealing with the telegram-form conveying systems employed by the General Post Office mention was made of the use of pneumatic transmission in connection with trunk and toll telephone exchanges. In these telephone systems the items transmitted consist of stiff paper tickets and not of telegram forms, so that the general heading given above is not, strictly speaking, accurate in so far as it relates to the present article. As, however, pneumatic tubes form part of the ticket-handling apparatus, this article may be justifiably considered as forming a continuation of the article commencing on page 535, *ante*, dealing with pneumatic transmission. In the first place, the purposes for which the tubes are employed in telephone exchanges may be briefly outlined. The tickets give details of telephone calls, the details being required for recording and filing purposes. The tickets have thus to be collected from a number of switchboard positions and transmitted to a central point known as the pneumatic dispatch position. The first operator may complete the call, in which case the ticket is dispatched to a filing position, or it may be necessary to pass it to a second operator to complete the call. In this case, the ticket is sent to a pneumatic dispatch position, whence it is sent to a suitable "Delay" operator and finally sent to a filing position. In certain cases, separate tubes are used for collecting tickets dealing with completed and uncompleted calls, but, generally, apart from London, all tickets are sent to a combined sorting, pneumatic dispatch and filing position. Transmission to the pneumatic dispatch position is by vacuum-operated tubes, and from that position by pressure-operated tubes.

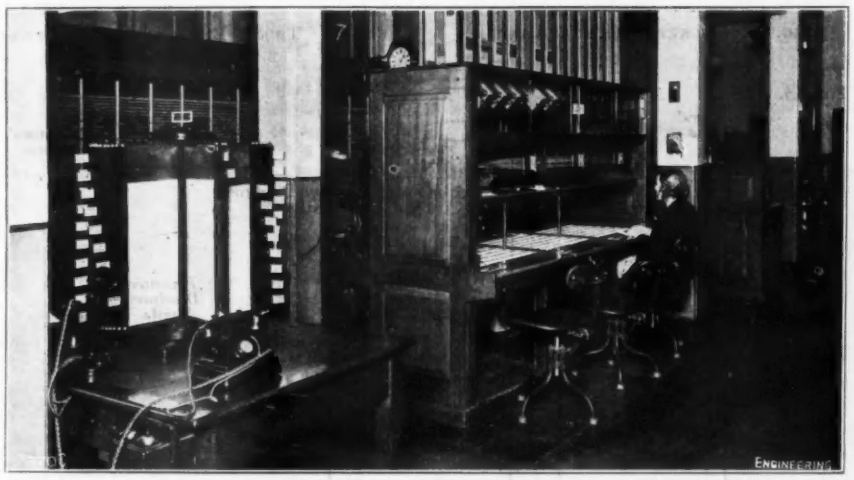


FIG. 60. TICKET-FILING POSITION; OVERSEAS EXCHANGE.

The ticket measures about 5¼ in. by 2⅜ in. and is made of a special heavy-weight paper. Before insertion in a tube it is turned up, at right angles, at one end for about ¼ in., the texture of the paper being such that there is no tendency for the sail thus formed to fold back again, either from its inherent elasticity or from the air pressure which propels the ticket. It would perhaps be more accurate, however, to say that the ticket is carried along in the moving air stream, since there is appreciable clearance between it and the tube. After a short acceleration period, the ticket travels with approximately the velocity of the air, the friction being negligible. In this connection it may be mentioned that the plain right-angle turn-up is preferred by the engineers of the General Post Office to the methods of folding adopted in other countries, all of which methods involve a doubling of the ticket into something resembling, in side view, an arrow-head. The pressure of the air inside the Vee thus formed causes the wings to expand and to fill the cross-section of the tube, with the result that there is not only considerable friction, but the risk of a block occurring with following tickets is increased.

The tubes through which the tickets are transmitted are of brass, 1 mm. thick, and have an internal cross-section of approximately 2¾ in. by ⅜ in. They are formed with a number of shallow longitudinal ridges internally, a construction which allows air to pass under the tickets and reduces friction. The general appearance of the tubes will be apparent from the views given in Figs. 57 and 58, but the corrugations are more marked in Fig. 59, all on Plate XXXVI. This view, moreover, is of particular interest as it shows how corners are negotiated. It will be evident that turning a tube through a right-angle bend in the plane of its width is not conducive to free passage of a ticket. Such a bend can be employed, provided the radius of the inner edge is not below a certain minimum but, in addition to its general unsuitability, this type of bend is difficult and expensive to make. When a tube has to turn off at a right angle, therefore, it is first twisted through 90 deg., as shown in the upper part of Fig. 59, and then bent through 90 deg. in the plane of its thickness. This illustration also shows, on the vertical leg of a tube at the left, one of the inspection doors which are fitted near bends and at intervals of 30 ft. on straight runs. These are held in place by screws, or springs and screws. If a blockage occurs, the cover is removed and a wire inserted to make the necessary clearance.

The joints in the tubes are generally made by means of sleeves, some of which are visible in the centre of Fig. 59. The sleeve is rendered airtight either by a special sealing compound or by a mixture of red lead and gold size. The edge of the tube facing the direction of flow is chamfered to prevent the ticket catching on it. The ticket pneumatic tubes, being for house use only, are much shorter than the circular-section street tubes previously described; a length of 350 ft. is regarded as the practical maximum, although tubes up to 500 ft. long have been recently installed. When long tubes are necessary for the lay-out, however, the total length may be divided into sections, the transfer of a ticket from one section to the other being effected automatically by a relay valve. This cutting of the tube into lengths is only practicable with vacuum-operated tubes. The maximum velocity of the air supplied to the tubes is regarded as 30 ft. per second in order to avoid undue expenditure of power, this velocity applying both to the pressure-operated tube ducts and to the vacuum-operated tube ducts, the volume of air to be set in motion being practically identical, whether it is discharged from the delivery outlet of a fan in the one case or extracted at its suction inlet in the other. The tickets formed with a back sail require only from 10 in. to 13 in. water gauge pressure to transmit them, which is about the same as that needed for the transmission of the telegram-form carriers in house tubes.

There are two types of pneumatic ticket-tube systems in use by the General Post Office, namely, the Mix and Genest system, of foreign origin, and the McGregor automatic system, both now manufactured in this country by Messrs. Standard Telephones and Cables, Limited. These systems are combined to a certain extent, owing to the fact that the Mix and Genest system is the older of the two and it has not been considered economical to displace it entirely and to provide a new type of apparatus throughout. The Mix and Genest pressure system has, therefore, been retained despite the advantages of the all-vacuum system, while the collecting tubes are operated by the very much simpler system devised to meet the requirements of the General Post Office by Mr. J. E. M. McGregor, A.C.G.I., of the staff of the Engineer-in-Chief. The Mix and Genest vacuum discharge valve, which required manual or motor operation, has been entirely superseded. It will be appreciated that in transmitting the tickets, the minimum of delay is aimed at and the discharge valve should, therefore, open of itself immediately a ticket arrives at it, closing at once when the ticket has passed through. The McGregor discharge valve is prominent, as an inclined rectangular box, in Fig. 57, on Plate XXXVI, and Fig. 60, on this page, but to understand its function the diagrammatic drawing, Fig. 63, page 616, should be referred to.

The structure seen in the centre of Fig. 63 is the pneumatic dispatch position to which tickets are delivered from the switchboard operators' positions on the left and from which they are dispatched to the switchboard operators' positions on the right if a call has to be put through from that position. Immediately above the pneumatic dispatch position is seen a McGregor discharge valve into which the ticket-collecting tube enters and which is coupled to the suction inlet of a centrifugal fan. This fan, which runs continuously, creates a low vacuum in the collecting tube, and therefore sets up an air stream flowing towards the discharge valve. The collecting tube, as indicated in Fig. 63, is open at its inlet end and is provided with a number of openings along its length distinguished as dispatch valves. These valves, which are, in principle, merely flaps, close the openings after the tickets have been inserted, and are situated conveniently to the operator. One valve is generally provided for two operators though, if the traffic on a particular table is heavy, each operator may have an individual dispatch valve. As many as ten such valves can be provided on one tube, so that it is possible for the tickets filled in by 20 operators to be handled by one McGregor discharge valve. The collecting tubes are grouped in runs overhead, or underneath the floor. It will be evident from the presence of a collecting tube on the table seen to the right of Fig. 63, that this table is also connected to the pneumatic dispatch position for the delivery of tickets to that position. Conversely, the switchboard table on the left of Fig. 63 may receive tickets from the pneumatic dispatch position. The diagram has been simplified as much as possible, as the precise lay-out of the various tables need not be discussed here.

Alarm devices are provided on vacuum-operated collecting tubes. These include an indicating lamp at each sending position or group of sending positions. The device is illustrated in Fig. 66, page 617. A light swinging aluminium strip *a* lies across the tube and the spindle on which it pivots is fitted with a torsion spring to give it a bias towards the alarm position. The strip is lifted by, and floats on, the air stream as long as air is flowing through the tube. A short arm *b*, attached to the pivot externally, keeps open the contacts of the alarm circuit as shown. Should a dispatch valve be left open, tickets block the tube, or should a breakdown of the exhausting fan occur, air in either case ceases to be drawn in at the open end of the collecting tube and the strip is drawn inwards by the torsion spring with the result that the contact is closed to operate the alarm. The arm *b* is secured to the pivot by a set screw so that precise adjustment can be made, and a stop prevents the strip from being lifted too far.

The external appearance of the McGregor valve itself is shown generally, in Figs. 61 and 62, on

* Part I of this series appeared on page 375 *ante*, Part II on page 429, *ante*, and Part III, on page 535, *ante*.

this page, which illustrate a model and not the actual valve as now made in quantity. The construction of the valve is illustrated in Figs. 64 and 65. It will be seen from these illustrations that the valve consists of an inner casing *a* and an outer casing *b*, the space between the two forming an air chamber with which the suction pipe *c* of the fan is connected. A throttle valve for regulating the degree of vacuum is inserted in this pipe. The inner casing, which is the valve proper, communicates with the outer casing through a number of small holes, the function of which is to by-pass the current of air as is explained later. The valve is closed by a door *d* pivoted approximately about its centre line and designed so that it is practically in exact balance with the forces acting upon it, viz., those due to the internal vacuum, external atmospheric pressure, and the pressure due to the impact of the column of air in the tube impinging on the lower half of the door. The latter is of importance and is compensated for by an adjustable slide *f*. This has a lining of felt, rubber or leather and varies the area of the top half of the door exposed to atmospheric pressure. The friction of the pivots is negligible. The door is just sufficiently out of balance to remain closed normally but to open on the impact of a ticket, which is led to the bottom of the valve by an extension of the ticket tube, indicated at *e*. The door has been removed in Fig. 61, in order to show the open end of this tube, but is in place in Fig. 62, in which view a ticket is seen in the act of falling to the receiving table after it has pushed open the door.

When the door opens, the exhausting of the collecting tube is not wholly interrupted, but is partially checked by the inrush of air round the door edges. The door has, therefore, to be dynamically as well as statically balanced. When the door opens there is still a flow of air out of the tube and through the by-pass holes, but there is a still greater rush direct from atmosphere, which tends to prevent the discharge of the ticket. This rush of air is checked by the number, size and distribution of the by-pass holes, which are also arranged so that when swinging the door is in dynamic balance with this force. The adjustment of the slide *f*, Figs. 64 and 65, is of great importance in enabling the same terminal to be used on any tube, irrespective of its length, but is very easy to effect. It will be obvious that the longer the tube the greater the resistance to the air flow within it, the slower the speed of transit, and the feebler the flow at the discharge point as the vacuum used is limited. As it is desirable to use a standard McGregor discharge valve on all tubes, *i.e.*, a valve with the same by-pass orifices and door, it is found that by admitting a small supplementary flow of air through an opening in the tube about $\frac{1}{4}$ in. to $\frac{1}{2}$ in. square, at a point about 20 ft. before the discharge terminal, perfect working can be obtained on tubes exceeding 300 ft. in length, an additional inlet being provided if necessary for very long tubes. It may be preferable, however, in these cases, to divide the tube in sections, as a higher speed of working can be obtained, and in such a case the ticket can be automatically discharged from one section to the next by means of a McGregor valve discharging the ticket into the next section through a specially shaped funnel. The connection to the fan suction is, of course, made from each valve. The adoption of this means depends, of course, on the transit time allowable.

At first sight this series method of working may seem unduly complicated, but the speeding-up of the transmission obtained by it is very marked. Thus the transit time on a continuous 300-ft. tube is about 22 seconds, while that on the same length of tube split up into two sections is about 14 seconds. The use of auxiliary air inlets enables a higher vacuum to be employed than would otherwise be possible, without rendering the adjustment of the balanced door too troublesome. Moreover, the additional inflow of air at the inlet points tends to keep tickets with accidentally flattened sails moving, and the conditions generally result in a slight increase in velocity. If traffic conditions permit, tubes up to 300 ft. long can be operated without auxiliary air inlets, though the ticket, in such a case, will not travel so fast as with the auxiliary air inlet system. What is aimed at in this method of working is to use the minimum degree of vacuum that will give prompt discharge at the McGregor valve, this vacuum being determined by a reading taken at a point on the tube a few inches from the valve and the vacuum being regulated by the throttle valve on the suction pipe from the fan. A satisfactory working vacuum is from $1\frac{1}{2}$ in. to 2 in. water gauge, measured at the first inspection cover, which is about 10 ft. from the nearest collecting valve.

Referring again to Fig. 63, the route of a ticket from the pneumatic distribution position to a switchboard is seen at the right. When the distribution is on the vacuum-operated McGregor system, the dispatching points consist of the open ends of the

TELEGRAM-FORM CONVEYING SYSTEMS; G.P.O.

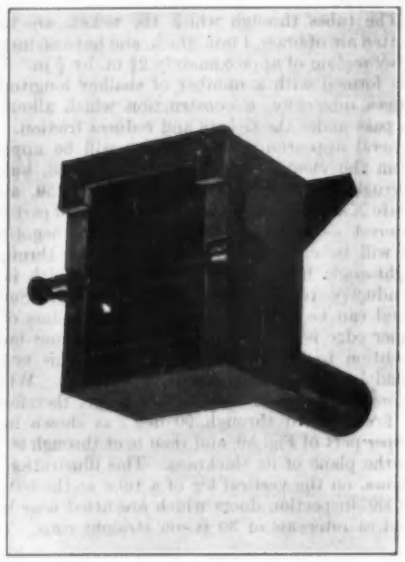


FIG. 61. TICKET-DISCHARGE VALVE.

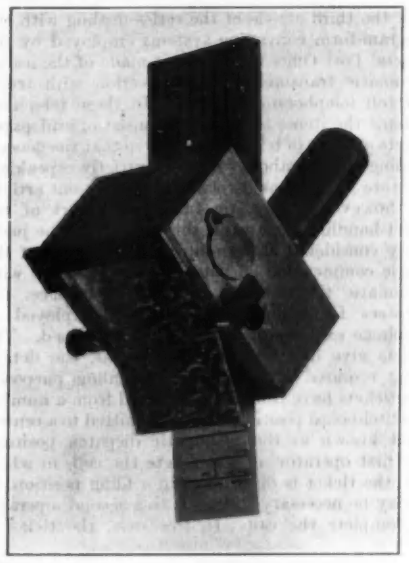


FIG. 62. TICKET BEING DISCHARGED FROM VALVE.

Fig.63.

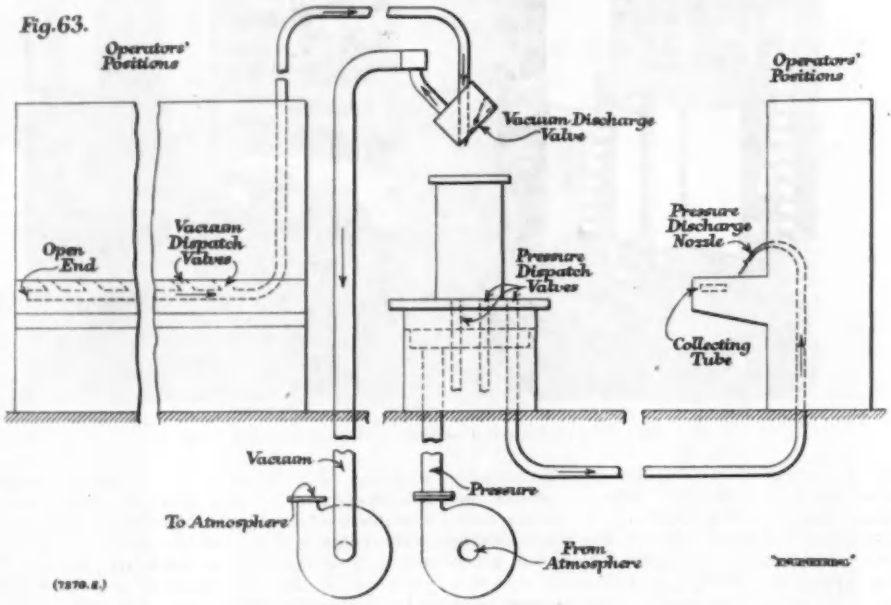


Fig.64.

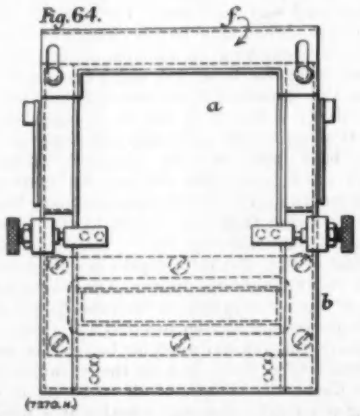
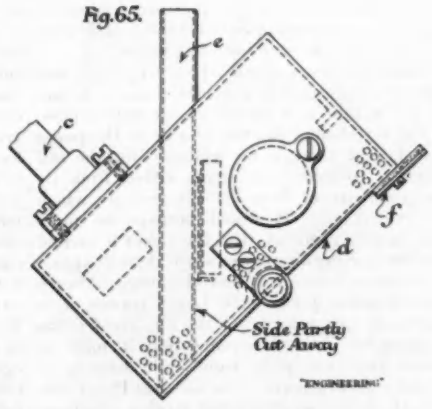


Fig.65.



TELEGRAM-FORM CONVEYING SYSTEMS: GENERAL POST OFFICE.

Fig. 66.

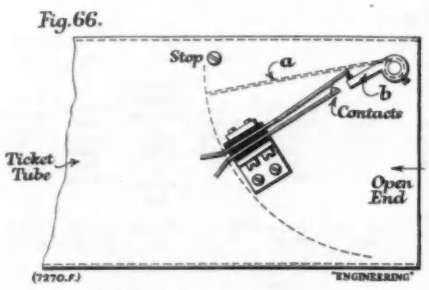


Fig. 69.

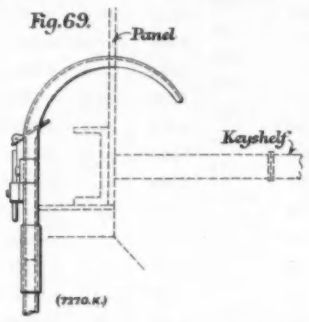


Fig. 67.

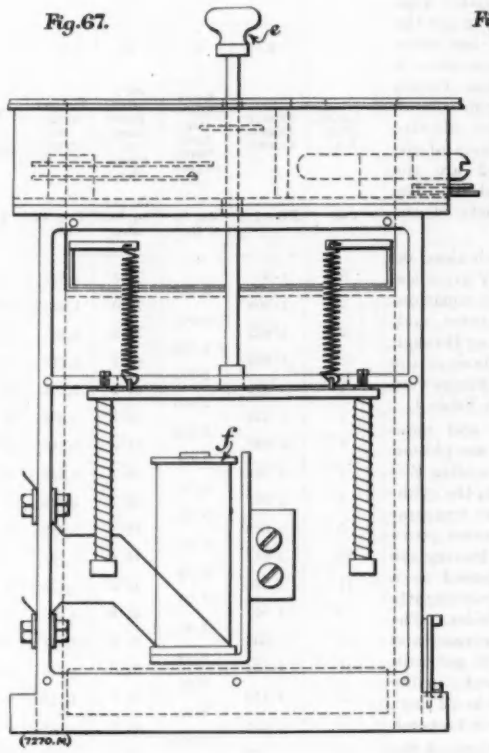
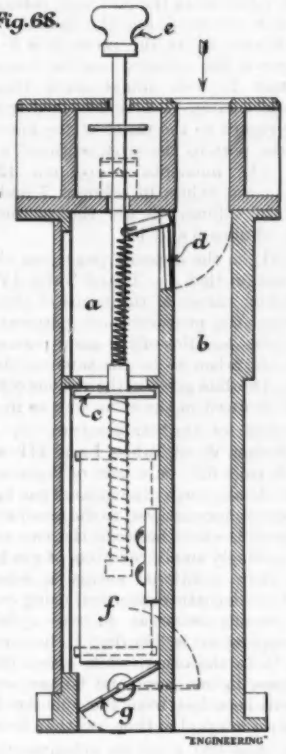


Fig. 68.



tubes arranged in a group on a suitable panel and having simple covers. When the pressure-operated Mix and Genest system is used, the dispatch points have to be fitted with a somewhat complicated form of valve embodying an air-lock. This valve is shown in Figs. 67 and 68, on this page. It consists of a casting containing a chamber *a* and an extension of the ticket tube *b*. At the top of the tube are two valves, one, indicated at *c*, covering an opening between the air supply and air chamber *a*, and the other, indicated at *d*, covering the slot through which the tickets are inserted and admitting air from the air chamber. The valve *c* is opened by the depression of the plunger *e*, held open by a magnet and closed on release by a spring. The valve *d* swings on a pivot. Normally, the ticket slot is open and the air in the chamber *a*, which communicates with the discharge side of a fan, cannot enter the tube. After the insertion of a ticket, however, depression of the plunger *e* admits air under pressure to the tube, the inrush of this air closing the slot by the automatic movement of the valve *d*. The ticket is then driven along the tube to the discharge point. Depression of the plunger *e*, in addition to actuating the valve *c*, closes an electric circuit which energises an electromagnet *f*, which holds down the valve *c* while the ticket is in transit. The circuit also illuminates a signal lamp. On the arrival of the ticket at the discharge end of the tube it strikes a trigger in the tube, the movement of the trigger breaking the electric circuit. The electromagnet *f* is, in consequence, de-energised and the signal lamp is extinguished. The trigger is seen in Fig. 69, above, near the termination of the discharge tube, which is open-ended and has one side curved over to deflect the ticket on to the table in front of the operator. Should the lamp continue to glow when a reasonable time has elapsed after the dispatch of a ticket, failure of the trigger is indicated. In these circumstances, a circuit-opening key is depressed. The electromagnet is de-energised and the air supply cut off automatically, this operation enabling the defect to be remedied. The butterfly valve *g* near the bottom of the chamber *a* is for regulating the air supply to the chamber and so adjusting the pressure to suit the length of the tube concerned.

The arrangement of the details described above is, to some extent, indicated in the photographs reproduced in Figs. 57, 58 and 60, which show parts of the telephone exchange in the Faraday Building. The pneumatic distribution position for the inland exchange is seen in Fig. 57 in a partially-equipped condition, a portion only of the ticket tubes having been installed when the photograph reproduced was taken. These tubes, which lead from the switchboard operators' positions, are seen at the top centre. The tickets are discharged from the McGregor valves into an open-bottomed trough running the full length of the cabinet and consisting of two inclined plate-glass strips. Below this, at each end of the cabinet, is a short flat-belt conveyor, the function of which is to collect the tickets discharged into the ends of the trough to the centre. The tickets in the central position fall directly from the trough in front of the sorters. The white objects seen on the desk in front of the sorters' chairs are the dispatch valves shown in detail in Figs. 67 and 68.

The view of the pneumatic distribution position for the overseas exchange given in Fig. 58 shows a somewhat different arrangement. The group of ticket tubes seen to the left are for dispatch, not receipt, hence the absence of McGregor valves. On the sloping desk seen immediately under the tubes are arranged the dispatch valves for the tubes, which are pressure-operated. The method of handling calls is different from that used in ordinary trunk working, the calls being taken first at the inquiry positions shown on the right of the distribution position. The operator having filled in the necessary details places the ticket on a band conveyor running along the top of the switchboard through one of the slots shown. As these inquiry positions are arranged in a comparatively short straight line, the use of a conveyor was more practicable than the use of tubes. The tickets are delivered to the sorter at the distribution position to dispatch to the appropriate operators. The final stage of ticket handling is seen in Fig. 60, page 615, which shows the ticket-filing position for the overseas exchange. In this view a number of ticket tubes are seen above the cabinet, those with labels in front being in use and fitted with McGregor discharge valves. The others, without valves, are provided for future extensions and were not in service when the photograph was taken. The tickets are guided by a glass open-bottomed trough on to a shelf in front of the sorter, from which shelf they are picked up and deposited in compartments of aluminium boxes. The boxes, clearly visible on the desk, measure approximately 21 in. by 15 in., and each contains 35 compartments. When full they are removed and conveyed by hand to a room where they are available for reference should any query be made regarding any particular message. As an indication of the volume of the traffic in Faraday Building, it may be mentioned that the average number of telephone tickets dealt with daily is 34,000, in a busy hour as many as 4,000 being handled. The number of ticket journeys involved is over 50,000 a day, or 6,000 in a busy hour.

It should be understood that the accounts of the telegram-form and telephone-ticket conveying systems given in this and the three preceding articles are simply an attempt to indicate the extent to which manual handling has been superseded by mechanical and pneumatic transmission, and that they do not claim to cover either the routine or exceptional working of the several departments of the General Post Office concerned. We cannot, however, conclude this series without recording our appreciation of the courtesy of Colonel A. S. Angwin, D.S.O., M.C., M.I.E.E., Engineer-in-Chief of the General Post Office, in permitting us to publish it, and of his help in providing the drawings and photographs from which our illustrations, with one exception, have been prepared. This exception is the photograph reproduced in Fig. 59, Plate XXXVI, for which we are indebted to Messrs. Standard Telephones and Cables, Limited, Connaught House, 63, Aldwych, London, W.C.2.

AN ANALYSIS OF CERTAIN CHARACTERISTICS OF A KADENACY ENGINE.

By PROFESSOR S. J. DAVIES, D.Sc., M.I.Mech.E.

(*Concluded from page* 559.)

IN the previous article, the energy equation was deduced, and it will now be instructive to employ the method of tabulation. Table I, on page 618, gives the final data for the first case, in which $t = 0 \cdot 864$ T, and Table II, on the same page, gives the values for the various terms of the equation used in obtaining Table I. The first four columns in Table I were given, and the temperature and mass at E O in columns 5 and 6 were those already deduced. The values in each step of Table II were obtained by trial, and from these solutions the values in columns 7 and 8 of Table I were obtained; the values in column 6 were obtained by subtraction. From the values in column 6, the corresponding temperatures in column

5 were calculated, and from the data in columns 4 and 5, the values of the mean densities of the gases in the cylinder, given in column 9, were obtained. The mean velocities in the port were calculated from the values in column 8, and the densities under the port conditions, where the pressure is 0·544 times the pressure in the cylinder, and the temperature is 0·864 times T, were found using these values. The data in column 11 were obtained from column 7, having regard to the ratios of the mean effective areas of the port to the cross-sectional area of the cylinder. The momenta in column 12 are the products of the values in columns 7 and 10. The momenta in column 13 are the products of the values in columns 6 and 11.

Table III, on the opposite page, was obtained on the assumption that $t = T$, and Table IV gives the corresponding values of the terms of the equation. In this case, the pressures and temperatures, and, therefore, the densities of the gases passing through the port, are taken to be the same as those in the cylinder. The data given in the various columns were otherwise deduced in the same way as in Table I.

The values of the temperature, T, and mass in the cylinder, W, of Tables I and III, are plotted in Fig. 11, page 620, on a base of degrees after E O and time. At any angle, the mass of gas in the cylinder is inversely proportional to the absolute temperature. The differences between the two cases prove to be surprisingly small, the mass of gas leaving the cylinder when additional energy is released as a result of the adiabatic expansion, being only slightly greater, leaving less gas in the cylinder. The fall of temperature is 300 deg. C. in one case, and 420 deg. C. in the other, while about 60 per cent. of the gases, in one case, and 65 per cent., in the other, have been lost from the cylinder in 22 deg., that is, in an interval of time less than 0·003 second.

Fig. 12, page 620, gives the velocities through the port, and the velocities of the centre of mass of the gases in the cylinder, plotted on a base of degrees after E O and time. It is noted that the velocity through the port begins at a value approaching 4,000 ft. per second, and then is quickly reduced to about 1,200 ft. per second, after which it rises somewhat to 1,500 ft. per second at 10 deg., then falls to a low value at 16 deg., and then rises again. When the port begins to open, there is complete discontinuity, but after motion of the external gases has begun, the outflow is no longer completely "unresisted," and lower values result. The fluctuations depend on the time-area of opening of the port, that is, on both the time rate of opening and the area at any instant, and also on the interaction between the gases leaving the cylinder and the external gases. Under the influence of the velocities through the port, and of the increasing area of opening of the port, the velocities of the centre of mass of the gases in the cylinder increase generally, with certain fluctuations during this period, and attain a high value by the end of the time. On Fig. 13, page 620, are plotted the masses of gas leaving the cylinder in each degree. These values again are the result of the two variables, velocity through the port and the area of the port. They increase to a maximum after 10 deg., then decrease to a minimum at 16 deg., and then again increase. The products of the masses and the velocities, that is, the momenta of the gases in the cylinder, and the momenta leaving the cylinder per degree, are plotted on the same base in Fig. 14, page 620. The broken curves in Figs. 13 and 14 show, respectively, the masses and the momenta passing the point P, Fig. 8, page 516, *ante*, per degree. The values on these curves were deduced from the diagrams of Fig. 9, page 516, *ante*, on the assumption of a mean value of 1,100 deg. C. abs. for the temperature. A lower temperature means, of course, an increase of the momenta passing P. The upstream Pitot tube at P was placed at the centre of the pipe, and there is evidence, not given here, that the distribution of mass over the cross-section of the pipe is not necessarily uniform. Further, the uncertainty of the values of temperature at P leads also to these values of mass and momentum not being very definite. Nevertheless, these curves give useful corroboration to the curves deduced from the cylinder diagrams, Figs. 6*a* and 6*b*, page 516, *ante*, both as regards the masses and as regards the momenta.

CHARACTERISTICS OF A KADENACY ENGINE.

TABLE I.

1. Angle after EO. Deg.	2. Proportionate Volume. EO = 1·0.	3. Mean Effective Area during Degree. Sq. ft. × 10^{-3}.	4. Indicated Pressure in Cylinder. lb. per sq. in. abs.	5. Temperature in Cylinder, T. Deg. C. abs.	6. Mass in Cylinder, W. Lb. × 10^{-2}.	7. Mass leaving Cylinder, $W_1 - W_2$. per deg. lb. × 10^{-4}.	8. Mass leaving Cylinder. Lb. per sec.	9. Density under Cylinder Conditions. Lb. per cub. ft.	10. Mean Velocity through Port. Ft. per sec.	11. Mean Vertical Velocity of Mass Centre in Cylinder. Ft. per sec.	12. Momentum leaving Cylinder per deg. Lb.-ft. per sec.	13. Momentum in Cylinder. Lb.-ft. per sec.
0	1·0	0·285	74·7	1,300	0·1849	0·132	0·102	0·0898	4,015	16·0	0·053	0·0295
1	1·008	0·957	73·0	1,290	0·18358	0·222	0·171	0·0884	2,042	27·36	0·0454	0·0499
2	1·015	1·665	71·2	1,283	0·18136	0·269	0·207	0·0866	1,452	33·8	0·0391	0·0609
3	1·023	2·285	69·2	1,277	0·17867	0·308	0·237	0·0846	1,240	39·6	0·0382	0·0701
4	1·031	2·951	67·1	1,268	0·17559	0·397	0·305	0·0826	1,273	52·2	0·0506	0·0906
5	1·038	3·533	64·7	1,259	0·17162	0·477	0·367	0·0808	1,313	64·9	0·0626	0·1099
6	1·046	4·09	61·9	1,249	0·16685	0·503	0·387	0·0774	1,244	71·1	0·0626	0·1170
7	1·054	4·74	59·1	1,238	0·16182	0·579	0·445	0·0746	1,288	85·3	0·0745	0·1356
8	1·062	5·38	56·0	1,226	0·15603	0·658	0·506	0·0714	1,352	101·8	0·0890	0·1553
9	1·069	6·03	52·7	1,212	0·14945	0·767	0·590	0·0679	1,483	125·1	0·1138	0·1821
10	1·077	6·72	48·9	1,194	0·14178	0·848	0·652	0·0639	1,570	147·7	0·1331	0·2030
11	1·084	7·28	44·9	1,173	0·13330	0·729	0·560	0·0597	1,329	155·1	0·0968	0·1751
12	1·091	7·84	41·6	1,159	0·12601	0·705	0·543	0·0561	1,273	139·7	0·0898	0·1710
13	1·098	8·49	38·5	1,141	0·11896	0·690	0·531	0·0527	1,227	145·7	0·0846	0·1682
14	1·104	9·05	35·6	1,128	0·11206	0·582	0·448	0·0493	1,033	130·9	0·0602	0·1430
15	1·110	9·51	33·2	1,116	0·10624	0·494	0·380	0·0465	882	117·3	0·0435	0·1216
16	1·116	9·98	31·2	1,104	0·10130	0·426	0·328	0·0441	764	106·7	0·0327	0·1057
17	1·122	10·50	29·5	1,097	0·09704	0·578	0·444	0·0420	1,040	152·8	0·0601	0·1438
18	1·129	10·96	27·2	1,083	0·09126	0·644	0·495	0·0392	1,196	200·0	0·0770	0·1762
19	1·136	11·40	24·7	1,063	0·08482	0·763	0·587	0·0363	1,490	287·6	0·1137	0·1920
20	1·142	11·79	21·8	1,038	0·07719	0·568	0·436	0·0328	1,174	193·6	0·0667	0·1430
21	1·148	12·09	19·8	1,021	0·07151	0·643	0·494	0·0302	1,418	240·0	0·0911	0·1638
22	1·154		17·5	998	0·06508			0·0274				

TABLE II.

Angle after EO. Deg.	I.	+ II.	− III.	− (VII + VIII).	= Left Hand Side.	IV.	+ V.	+ VI.	= Right Hand Side.
	(Expressed in Centigrade Heat Units.)								
0	0·5197	0	0·5119	0·001215	0·00659	Negl.	0·004212	0·002389	0·00655
1	0·5119	Negl.	0·5028	0·00103	0·00807	0·000020	0·007018	0·001022	0·00806
2	0·5028	0·000020	0·4926	0·0011	0·00912	0·000031	0·008482	0·000634	0·00914
3	0·4926	0·000031	0·4813	0·0011	0·01023	0·000042	0·009656	0·000524	0·01022
4	0·4813	0·000042	0·4673	0·0009	0·01315	0·000072	0·012370	0·000718	0·01316
5	0·4673	0·000072	0·4506	0·0010	0·01577	0·000109	0·014750	0·000921	0·01578
6	0·4506	0·000109	0·4334	0·0009	0·01641	0·000126	0·015425	0·000869	0·01642
7	0·4334	0·000126	0·4138	0·0009	0·01883	0·000178	0·017596	0·001068	0·01884
8	0·4138	0·000178	0·3919	0·0007	0·02138	0·000240	0·019800	0·001337	0·02138
9	0·3919	0·000240	0·3664	0·0007	0·02504	0·000351	0·022780	0·001882	0·02501
10	0·3664	0·000351	0·3386	0·0006	0·02755	0·000461	0·024775	0·002302	0·02754
11	0·3386	0·000461	0·3158	0·0005	0·02276	0·000365	0·020965	0·001434	0·02276
12	0·3158	0·000365	0·2942	0·0003	0·02167	0·000366	0·020010	0·001270	0·02165
13	0·2942	0·000366	0·2734	0·0003	0·02087	0·000377	0·019315	0·001165	0·02086
14	0·2734	0·000377	0·2564	0·0003	0·01708	0·000285	0·016090	0·000690	0·01707
15	0·2564	0·000285	0·2423	0·0002	0·01419	0·000217	0·013520	0·000426	0·01416
16	0·2423	0·000217	0·2303	0·0002	0·01202	0·000172	0·011570	0·000282	0·01202
17	0·2303	0·000172	0·2137	0·0002	0·01657	0·000341	0·015540	0·000709	0·01659
18	0·2137	0·000341	0·1953	0·0002	0·01854	0·000458	0·017050	0·001022	0·01853
19	0·1953	0·000458	0·1733	0·0001	0·02256	0·000715	0·019765	0·001882	0·02236
20	0·1733	0·000715	0·1582	0·0001	0·01572	0·000432	0·014420	0·000871	0·01572
21	0·1582	0·000432	0·1405	0·0001	0·01807	0·000615	0·016015	0·001446	0·01808
22									

The state of affairs at the instant A O is such that the greater part of the cylinder gases has left the cylinder, and has passed the point P at high velocity, and thus possesses high momentum. The gases remaining in the cylinder have also acquired a considerable momentum towards the exhaust

CHARACTERISTICS OF A KADENACY ENGINE.

TABLE III.

1. Angle after EO. Deg.	2. Proportionate Volume. EO = 1·0.	3. Mean Effective Area during Degree. Sq. ft. × 10^{-3}.	4. Indicated Pressure in Cylinder. Lb. per sq. in. abs.	5. Temperature in Cylinder, T. Deg. C. abs.	6. Mass in Cylinder, W. Lb. × $10.^{-2}$	7. Mass leaving Cylinder, $W_1 - W_2$. Per deg. lb. × 10^{-4}.	8. Mass leaving Cylinder. Lb. per sec.	9. Density under Cylinder Conditions. Lb. per cub. ft.	10. Mean Velocity through Port. Ft. per sec.	11. Mean Vertical Velocity of Mass Centre in Cylinder. Ft. per sec.	12. Momentum leaving Cylinder per deg. Lb.-ft. per sec.	13. Momentum in Cylinder. Lb.-ft. per sec.
0	1·0	0·235	74·7	1,300	0·1849	0·124	0·0954	0·0898	3,758	14·97	0·0466	0·0276
1	1·008	0·957	73·0	1,289	0·18366	0·200	0·1539	0·0885	1,833	24·75	0·0383	0·0451
2	1·015	1·665	71·2	1,280	0·18166	0·238	0·1831	0·0869	1,279	29·8	0·0304	0·0538
3	1·023	2·285	69·2	1,271	0·17928	0·272	0·209	0·0850	1,089	34·8	0·0296	0·0619
4	1·031	2·931	67·1	1,261	0·17656	0·352	0·271	0·0831	1,128	46·2	0·0397	0·0808
5	1·038	3·533	64·7	1,250	0·17304	0·425	0·327	0·0808	1,167	57·6	0·0495	0·0985
6	1·046	4·09	61·9	1,236	0·16879	0·447	0·344	0·0781	1,093	62·5	0·0490	0·1040
7	1·054	4·74	59·1	1,221	0·16432	0·519	0·399	0·0756	1,138	75·4	0·0590	0·1218
8	1·062	5·38	56·0	1,203	0·15913	0·594	0·457	0·0727	1,194	89·9	0·0709	0·1403
9	1·069	6·03	52·7	1,184	0·15319	0·700	0·539	0·0697	1,319	111·1	0·0923	0·1662
10	1·077	6·72	48·9	1,159	0·14619	0·778	0·599	0·0659	1,393	131·0	0·1083	0·1867
11	1·084	7·28	44·9	1,132	0·13841	0·668	0·514	0·0619	1,171	119·1	0·0782	0·1610
12	1·091	7·84	41·6	1,110	0·13173	0·650	0·500	0·0586	1,119	122·8	0·0727	0·1579
13	1·098	8·49	38·5	1,087	0·12523	0·641	0·494	0·0554	1,082	128·6	0·0695	0·1568
14	1·104	9·05	35·6	1,065	0·11882	0·542	0·417	0·0522	906	114·7	0·0491	0·1332
15	1·110	9·51	33·2	1,046	0·11340	0·461	0·355	0·0496	771	102·7	0·0358	0·1140
16	1·116	9·98	31·2	1,031	0·10879	0·398	0·306	0·0472	662	92·4	0·0264	0·0986
17	1·122	10·50	29·5	1,016	0·10481	0·548	0·421	0·0454	912	134·0	0·0500	0·1369
18	1·129	10·96	27·2	995	0·09933	0·618	0·475	0·0427	1,050	175·7	0·0649	0·1690
19	1·136	11·40	24·7	970	0·09315	0·743	0·571	0·0398	1,315	209·8	0·0957	0·1873
20	1·142	11·79	21·8	936	0·08572	0·554	0·426	0·0364	1,028	169·3	0·0569	0·1403
21	1·148	12·09	19·8	911	0·08018	0·638	0·491	0·0340	1,247	210·6	0·0795	0·1622
22	1·154		17·5	880	0·07380			0·0311				

TABLE IV.

Angle after EO. Deg.	I.	+ II.	− III.	− (VII + VIII).	= Left Hand Side.	IV.	+ V.	+ VI.	= Right Hand Side.
	(Expressed in Centigrade Heat Units.)								
0	0·5197	0	0·5119	0·001215	0·00658	Negl.	0·004579	0·001962	0·00654
1	0·5119	Negl.	0·5028	0·00103	0·00807	0·000017	0·007328	0·000747	0·00809
2	0·5028	0·000017	0·4926	0·0011	0·00912	0·000024	0·008660	0·000430	0·00911
3	0·4926	0·000024	0·4813	0·0011	0·01022	0·000032	0·009825	0·000358	0·01022
4	0·4813	0·000032	0·4673	0·0009	0·01313	0·000056	0·01261	0·000496	0·01316
5	0·4673	0·000056	0·4506	0·0010	0·01576	0·000085	0·01506	0·000640	0·01578
6	0·4506	0·000085	0·4334	0·0009	0·01638	0·000098	0·01566	0·000594	0·01635
7	0·4334	0·000098	0·4138	0·0009	0·01880	0·000139	0·01795	0·000742	0·01883
8	0·4138	0·000139	0·3919	0·0007	0·02134	0·000191	0·02022	0·000952	0·02136
9	0·3919	0·000191	0·3664	0·0007	0·02499	0·000282	0·02339	0·001350	0·02502
10	0·3664	0·000282	0·3386	0·0006	0·02748	0·000373	0·02543	0·001678	0·02748
11	0·3386	0·000373	0·3158	0·0005	0·02267	0·000292	0·02136	0·001020	0·02267
12	0·3158	0·000292	0·2942	0·0003	0·02159	0·000296	0·02037	0·000900	0·02157
13	0·2942	0·000296	0·2734	0·0003	0·02080	0·000306	0·01968	0·000835	0·02082
14	0·2734	0·000306	0·2564	0·0003	0·01701	0·000232	0·01631	0·000494	0·01704
15	0·2564	0·000232	0·2423	0·0002	0·01413	0·000177	0·01366	0·000304	0·01414
16	0·2423	0·000177	0·2303	0·0002	0·01198	0·000138	0·01162	0·000194	0·01195
17	0·2303	0·000138	0·2137	0·0002	0·01654	0·000280	0·01572	0·000509	0·01651
18	0·2137	0·000280	0·1953	0·0002	0·01848	0·000384	0·01732	0·000762	0·01847
19	0·1953	0·000384	0·1733	0·0001	0·02228	0·000611	0·02025	0·001430	0·02229
20	0·1733	0·000611	0·1582	0·0001	0·01561	0·000367	0·01461	0·000649	0·01563
21	0·1582	0·000367	0·1405	0·0001	0·01797	0·000535	0·01632	0·001112	0·01797
22									

port, although their static pressure has not yet fallen to atmospheric. At A O, the admission port begins to open, and almost immediately the new charge begins to enter the cylinder, as shown on Figs. 4 and 5, page 516, *ante*. The opening of the admission port in this way naturally permits the atmospheric air to enter the cylinder behind the retreating exhaust gases, and, in this particular test, the measurements at the centre of the cylinder show at no instant a static depression in the cylinder exceeding 1¼ lb. per square inch. In this case, however, the admission gases enter the cylinder at once, and continue to enter even though there is a depression in the admission pipe, and at the admission port, for a good part of the admission period.

On the evidence deduced from the present test, therefore, the process can be described as follows: On opening the exhaust port, the time-area rate is sufficient to allow the exhaust gases to pass out with the high velocities measured, and to impart their momentum to the external gases, which, at E O, were practically at rest outside the exhaust port. As a result of this momentum, the exhaust gases and the external gases move away from the cylinder. The momentum of the gases still in the cylinder at A O, causes them to continue to move out of the cylinder, and away from the exhaust port. The effect of these momenta might be compared with that of a scavenging piston moving through the cylinder and along the exhaust pipe away from the exhaust port. There appears from the diagrams on Fig. 6*a* to be no discontinuity between the retreating exhaust gases and the new charge entering from the atmosphere through the admission port, and, during the greater part of the charging period, the pressure in the cylinder is shown as a depression of 0·5 lb. to 1·0 lb. per square inch. In a test under similar conditions, one of the two admission ports was closed, and a pressure-measuring unit was applied at the closed port. This showed that, at this point, where motion of the incoming gases was prevented, there was a static depression of 2 lb. per square inch. The depression causing the entry of the new charge through the open ports, in the present case, must therefore be regarded as a "dynamic" depression, as distinct from the static depression which can be shown to exist when the admission ports are restricted. (See also the author's letter in ENGINEERING, vol. 148, page 207, 1939).

The pressure in the cylinder rises above atmospheric at 97 deg., and this may be due to one of two causes: firstly, the atmospheric air which has entered the cylinder, and of which some has passed out through the exhaust port, may meet a resistance in the pipe outside, such as is indicated in Fig. 9, page 516, *ante*. On being decelerated, the new charge tends to pile itself up in the cylinder and in the exhaust pipe, with consequent increases of pressure. The exhaust port is, however, gradually closing, and there is no effect from outside this port after 104 deg. Secondly, the momentum of the exhaust gases, and of the external gases to which it has been communicated, will be dissipated more and more as greater and greater masses of external gas come under its influence, and there is evidence of the progress of a return motion of the gases towards the exhaust port. In some combinations of circumstances, the latter may predominate over the former, and may supercharge the cylinder backwards through the exhaust port, the new air which had previously passed out through the exhaust port being forced backwards into the cylinder. Concurrently with both these actions there is the fact that the pistons are now moving together again, and the volume enclosed between them is being reduced.

Before drawing conclusions from this analysis it is perhaps desirable to point out certain respects in which, in the author's view, the measurements given above could profitably be supplemented. First of all, it was found practicable to take pressure measurements at only one point in the cylinder, namely, at the wall near the middle. The distribution of static pressure, velocity, temperature and density, that is, the distribution of the mass of the gases in the cylinder, remains unmeasured, and the simplest treatment appeared to be to take the velocity distribution as linear from top to bottom, and to assume the temperature, pressure and density as uniform in general. In the case with adiabatic expansion, given in Tables I and II, there are, of course, superimposed on this generally uniform distribution, corresponding changes of pressure, temperature and density in an indefinite, but restricted, volume from the cylinder to the port. As stated

CHARACTERISTICS OF A KADENACY ENGINE.

Fig. 11. MASSES & TEMPERATURES

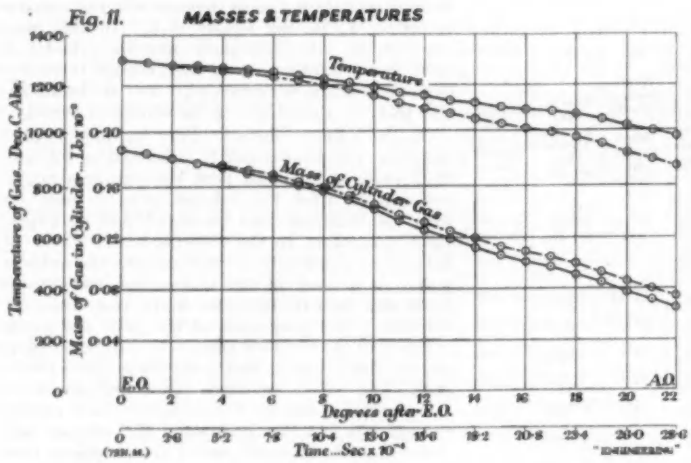


Fig. 12. VELOCITIES

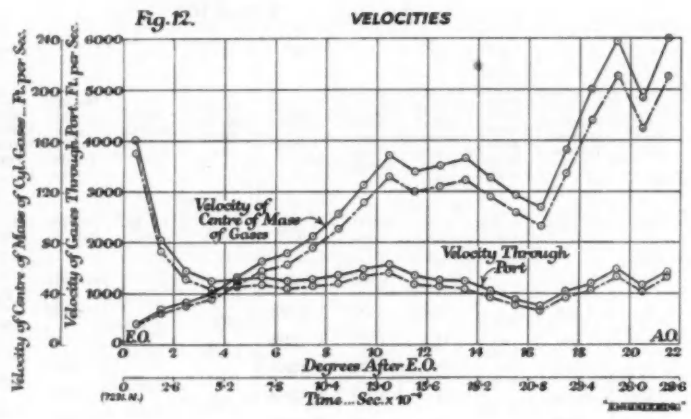


Fig. 13. MASSES

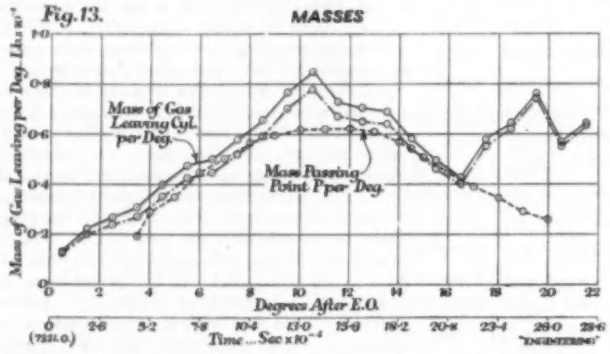
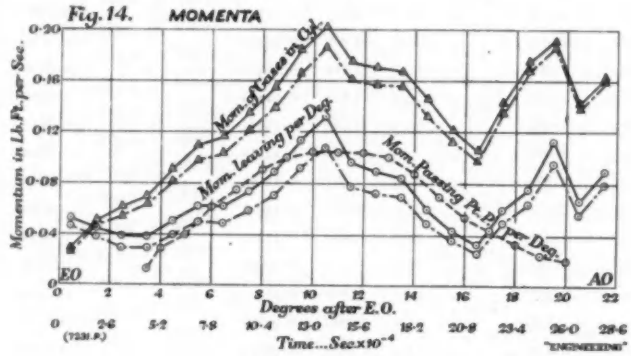


Fig. 14. MOMENTA



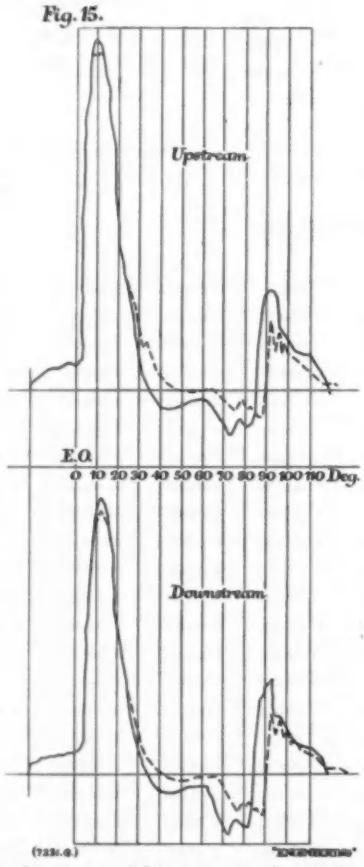
earlier, the lack of means for measuring even the mean densities or temperatures in the gases rendered necessary an indirect deduction of the temperature.

In the treatments based on continuous flow, the "throat" of the convergent-divergent nozzle is taken as the port opening, and a suitable coefficient of discharge is assumed. The author has followed this method in both the cases of Tables I and III, and has taken 0·8 throughout as the value of the coefficient. In view of the pressures recorded at P in Fig. 9, page 516, *ante*, however, the evidence in support of the use of this assumption in the present case is very uncertain. Measurements at the exhaust port, unfortunately impracticable, might have thrown light on this matter. In these treatments, too, the whole of the energy to produce the velocity through the port is calculated from that available from the adiabatic expansion of the gases from the cylinder to the port. Between the values of velocity in Tables I and III there is little difference, the increase of velocity following the adiabatic expansion being small. All this is consistent with the view expressed earlier, that treatments based on continuous flow are quite incomplete in connection with the phenomena in actual engines.

Altogether, the author feels that, with regard to the properties of gases, the knowledge applied at present to internal-combustion engines is very incomplete. This is a fundamental matter in which the engineer may justifiably expect more guidance from the physicist, in order to fill up such gaps as those indicated above. In considering the present experimental treatment, the author finds further satisfactory support for the opening statement of his earlier report, namely:

"The basic contribution that Kadenacy has made to engine design is his discovery that, immediately on rapidly opening the exhaust ports of an engine during the expansion stroke, there is, within the first interval of time for a few thousandths of a second, an urge or impulse in the gases within the cylinder to escape very rapidly from the cylinder, leaving behind them a depression. By suitable timing of the admission valve or port, the new charge is arranged to enter the cylinder behind the retreating exhaust gas. These actions are found to occur with suitable port design and timing, and no

Fig. 15.



scavenging pumps, inlet pipes or exhaust pipes are necessary to enable such an engine to run and deliver power. This extremely rapid exit of the exhaust gases may conveniently be termed ballistic, and experiment shows that it depends only on time."

The present analysis demonstrates that this so-called "ballistic" exit of the gases is the dominating factor in establishing the conditions leading to the direct charging of the cylinder, in this case from the atmosphere, through the admission port. The kind of interaction occurring between the gases leaving the exhaust port and the external gases is shown in Fig. 9, page 516, *ante*, and the exhaust organ must facilitate the exit of the gases from the cylinder. This organ must be dimensioned to meet the practical conditions of running, that is, so that the charging will give the necessary order of B.M.E.P. over the speed range desired.

APPENDIX.

In describing the exhaust system shown in Fig. 8, page 516, *ante*, reference was made to the supplementary volume shown after the measuring point P, and it was stated that, for the purposes of the present analysis, the effect of this extra volume may be neglected. Fig. 15, on this page, shows two pairs of diagrams taken at a point 9¼ in. from the exhaust port, and thus beyond the position of the supplementary volume. One pair are upstream diagrams and the other downstream diagrams, taken from this point, with the engine running at 1,200 r.p.m., and developing a B.M.E.P. of 99·7 lb. per square inch. The diagrams show pressure on a base of crank angle after E O, but the pressures were not calibrated and thus no scale is given. The broken lines show the conditions with, and the firm lines without, the supplementary volume. It is noticed that the curves follow practically the same course in both pairs for the first 24 deg. after E O. Ignoring the interval of time between action at the exhaust port and action at this measuring point, the differences shown, and occurring subsequently, can have no effect on the motion of the gases passing through the exhaust port during the first 22 deg. from E O, that is, during the interval dealt with in Tables I to IV. While the later differences are important in relation to the general engine performance, they, therefore, do not enter into the present analysis.

AMERICAN STEEL PRODUCTION.—According to statistics issued by the American Iron and Steel Institute, the production of steel ingots and castings in the United States totalled 52,798,714 net tons during 1939.

70-FT. ARTICULATED LOCOMOTIVE TURNTABLE FOR L.M.S. RAILWAY.

MESSRS. COWANS, SHELDON AND COMPANY, LIMITED (ENGINEERS), CARLISLE.

(For Description, see page 621.)

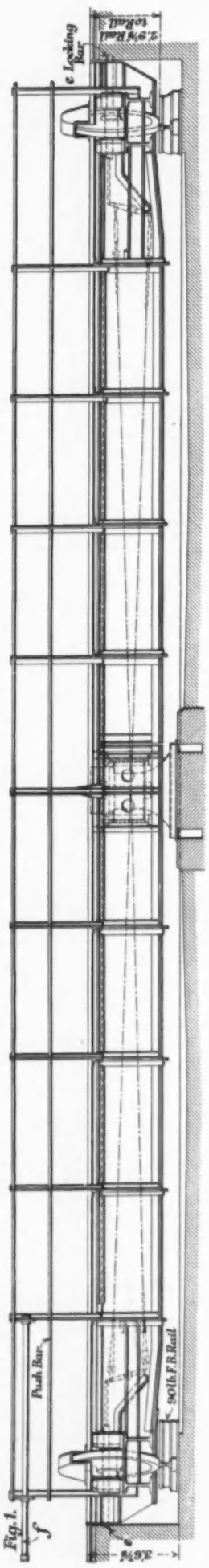


Fig. 1.

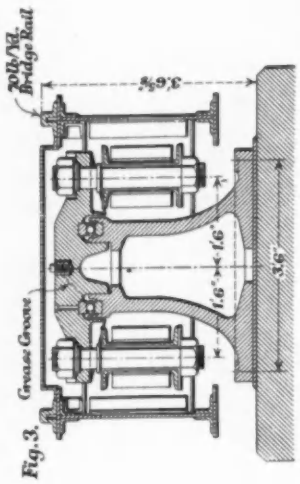


Fig. 3.

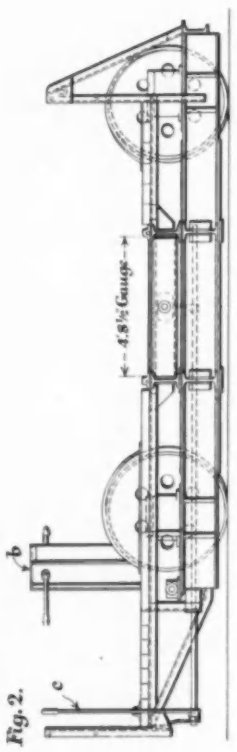


Fig. 2.

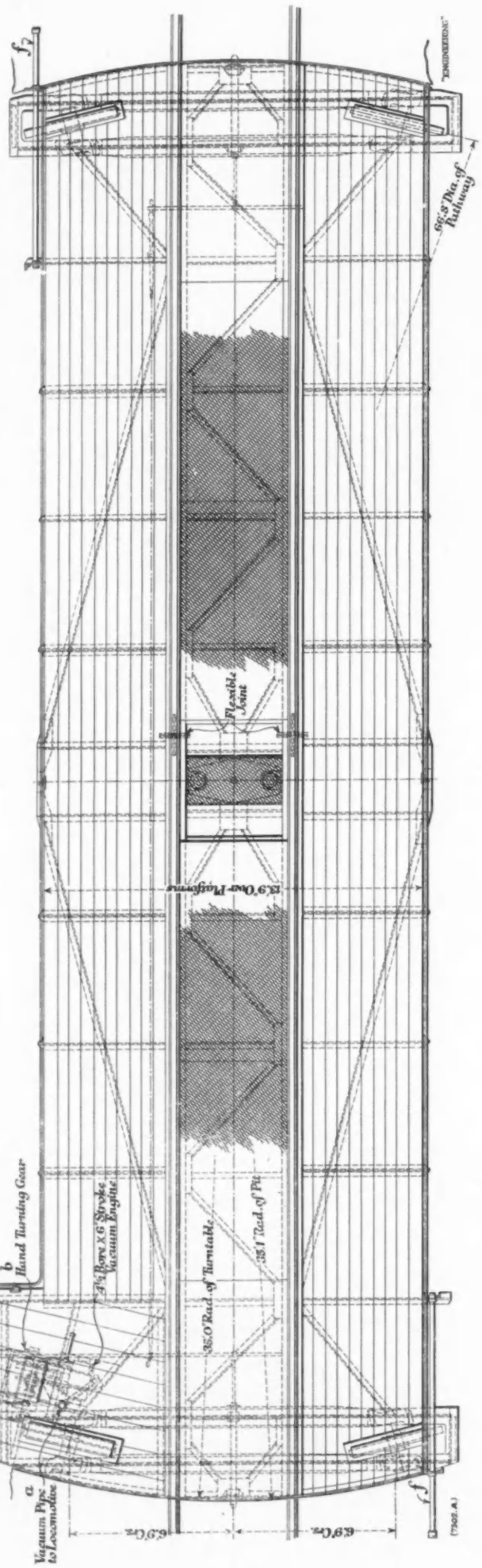


Fig. 4.

(To face page 621.)

UNIV. OF MICH.

10-GALLONS PER HOUR EMULSIFIER.

MESSRS. IMPROVED EMULSIFICATION PROCESS COMPANY, LIMITED, LOUGHBOROUGH.

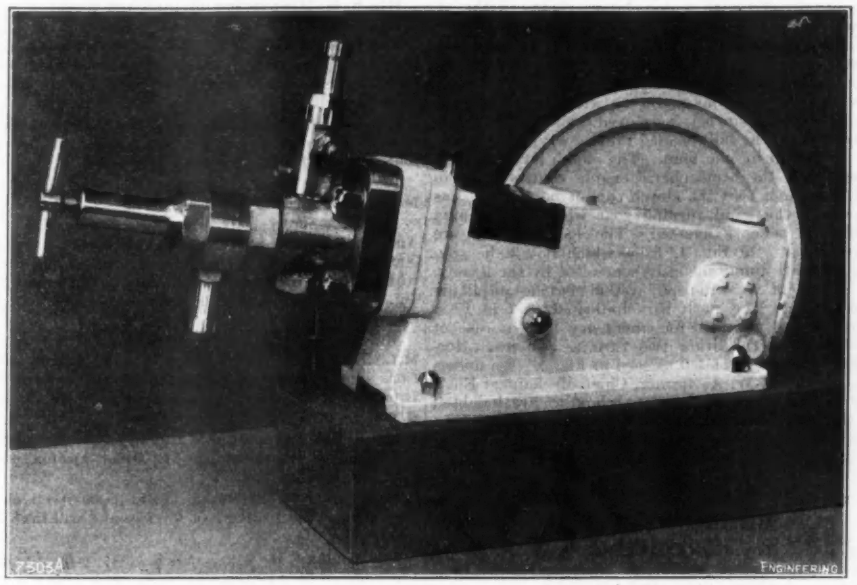
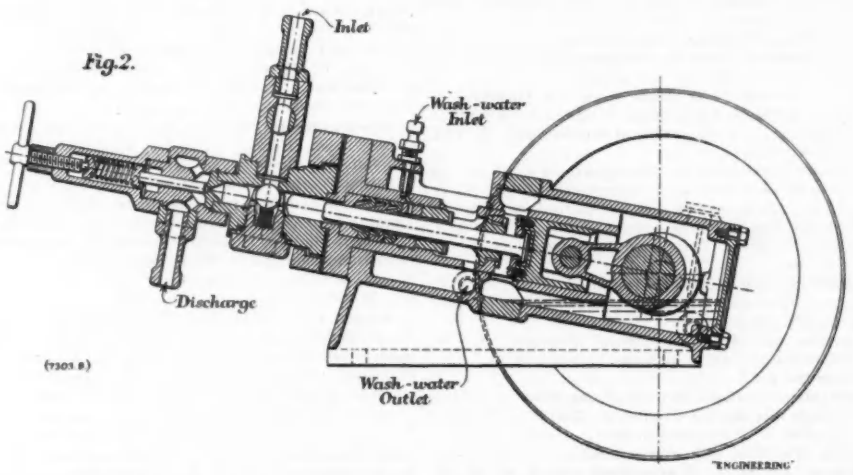


FIG. 1.



THE "IMPULSOR" EMULSIFIER.

THE process of homogenisation, or the mixing of fluids and such solids as fatty substances to form a stable fluid which is not liable to subsequent separation, is too well known to call for detailed explanation here, as is the extent to which the process is now employed in the manufacture of various foodstuffs and chemical products. The machinery employed has, moreover, been previously treated fairly fully in our columns, notably that manufactured by Messrs. The Brush Electrical Engineering Company, Limited, Loughborough, examples of this firm's machines having been described and illustrated in ENGINEERING, vol. 137, page 146 (1934) and in vol. 141, page 419 (1936). These machines, however, were of large output capacity, that dealt with in the first-mentioned article having an output of 750 gallons per hour and being now manufactured in a range of sizes with outputs of from 25 gallons to 1,000 gallons per hour. Wide though this range is, there was still a gap to be filled, a small machine being needed for the processing of experimental emulsions in the laboratory and for commercial use where only a small output is needed. Messrs. The Brush Electrical Engineering Company therefore took over the manufacturing and selling rights of the "Impulsor" emulsifier, formerly made at Greenford, Middlesex. The machine here described and illustrated in the accompanying Figs. 1 and 2, is now manufactured by a Brush subsidiary company, Messrs. Improved Emulsification Process Company, Limited, Loughborough. The output of 10 gallons per hour, which is the nominal size of the machine, is an average figure, the actual output varying from 8 gallons to 12 gallons per hour, this variation depending on the viscosity of the material being processed. For the new small machine it is claimed that its high efficiency enables it to supersede the rotating type of emulsifier since it effects a great saving in the quantity of stabiliser used in a given emulsion, while the texture, stability and appearance of the finished product is greatly improved. Moreover, the construction of the machine is such that it can be used for long periods daily without skilled attention and can be easily cleaned and sterilised without incurring the risk of one product contaminating a succeeding one.

From the external view, Fig. 1, and the section, Fig. 2, it will be realised that the machine is very compact, since the overall length is only 2 ft. 4 in., the overall width 8½ in., and the overall height 11 in. It is driven by belt on a flat flywheel-pulley 12 in. in diameter, power being supplied either from line shafting or by an electric motor. A motor of 1 h.p. is sufficient to drive it at its maximum pressure of 3,250 lb. per square inch. The running speed is 275 r.p.m., and rotation can be in either direction. The bed seat is 12¾ in. long by 6 in. wide, and four ¾-in. bolts are sufficient to anchor the machine firmly. Referring to Fig. 2, the reciprocating movement of the ram is seen to be derived from an eccentric integral with the shaft, the sheave of which is formed as a short connecting rod coupled to a cylindrical crosshead. The ram is secured to the crosshead by a cap ring, the end of the ram being formed with a flange bearing on both sides on renewable discs. The ram passes out of the crank chamber through a plain gland, the crank chamber being wholly enclosed and containing oil.

The ram is of stainless steel coated with chromium by a process giving a hard wearing surface. It is carried in a stainless-steel sleeve supported in the main casting and provided with packing of the hydraulic type. The connection seen above the packing is for coupling to a clean-water supply so that the gland is washed and sealed, an outlet in the body casting permitting a constant flow of water to be used. This arrangement enables the machine to handle foodstuffs without risk of bacterial contamination from non-sterile packings. The water seal, moreover, permits pumping to proceed consistently when viscous products are being dealt with, as it eliminates any tendency for air to leak along the ram and through the packings on the suction stroke. The pump body, which carries the suction valve and the discharge and homogenising valve, is held by a loose spigoted flange, with four set screws, as seen in Fig. 1, these screws also holding the packing sleeve in place. The parts are made of stainless steel.

The suction valve is of the spring-loaded ball type and is housed in a combined guide and cleaning plug. It is situated immediately under the inlet connection, so that there is a straight-through passage for cleaning. The discharge and homogenising valve consists simply of a flat-ended rod, capable of reversal, which abuts on a nozzle-shaped seat. The valve is held against the seat by a strong spring, the degree of compression of which can be varied within wide limits by a screw fitted with a hand grip. The operation of the machine is as follows: The inlet is connected to a small tank or other pre-mixing device, the mixture being drawn into the cylinder on the suction stroke. On the return, or compression, stroke, the suction valve closes automatically, and the pressure rapidly rises to a value determined by the adjustment of the discharge-valve control spring. The rise of pressure eventually causes the valve to open, though only to a minute degree, and the small area of the orifice thus provided results in a discharge of a portion of the contents of the cylinder at an extremely high velocity. The undischarged portion in the cylinder is mixed with a fresh supply on the next suction stroke and the cycle of operations is continued. An intimate admixture of the phases is brought about, the disperse or oil phase being reduced to a very fine state of subdivision from the high shearing force to which it is subjected by its passage through the restricted orifice of the discharge valve. The design of the discharge valve, moreover, ensures the effective dispersion of these small globules in the dispersion medium. This thorough subdivision and dispersion, in conjunction with the stabiliser, breaks down the surface tension of the globules and prevents the cohesion of several small globules, which, in the form of a single larger globule, would separate out by reason of the difference in density between them and the dispersion medium. The net result of the process is, therefore, the production of a perfectly stable emulsion.

70-FT. LOCOMOTIVE TURNTABLE FOR THE L.M.S. RAILWAY.

THE well-known pattern of locomotive turntable, in which the rotation of the table is effected by laborious hand operation, is now being largely replaced by tables of the power-operated type. A typical turntable of this kind, on the system of the London Midland and Scottish Railway Company is shown in Figs. 1 to 6, on page 624, and on Plate XXXVII, this particular example having been supplied by Messrs. Cowans, Sheldon and Company, Limited, London-road, Carlisle. The turntable has an overall diameter of 70 ft. and is capable of turning all classes of engine and tender up to a total weight of 175 tons. From the general view, Fig. 5, page 624, it might appear at first sight that the turntable was of conventional design. Examination of the drawings of Figs. 1 to 4, Plate XXXVII, will show, however, that this is not the case, since the girder on which the rails are carried is not continuous, but is provided with a flexible joint, so that it can adapt itself to the load in whatever position the locomotive may be. This type of turntable is known as the non-balanced or articulated turntable. It will be realised that with a table having a continuous girder, the load, unless it be accurately balanced, tends to tilt the whole table, with the result that the pathway wheels on which the assembly is rotated may actually leave the pathway rail at one side.

With the articulated table, on the other hand, the load is not only definitely shared between the centre pivot and the pathway wheels, but all these wheels remain in contact with the circular rail irrespective of the position and loading of the locomotive. Moreover, there can be no violent impact between the pathway wheels and the rail when the locomotive runs on or off the table, this jolting being a common occurrence with the older type of table. The general construction of the table comprises a pair of heavy girders carrying

the rails, which are of standard gauge and of a bridge section weighing 70 lb. per yard. The girders are suitably cross-braced and are provided at each side with a structure carrying a timber platform and handrails. The space between the rails is filled in with chequer plates. At each end, the main girders are bolted to a pair of cross-girders, on the top of which are the bearings for the pathway wheels. At one end, the gangway structure is extended on one side to carry the atmospheric engine supplying the turning power and the hand-operated turning gear, as shown in the plan, Fig. 4. The turntable rotates in a pit 70 ft. 2 in. in diameter, so that there is a clearance of 1 in. all round the table. The pathway rail is 66 ft. 8 in. in diameter on the rail centre. The rail is of flat-bottomed section weighing 90 lb. per yard.

The pathway wheels are 4 ft. in diameter and have plain rolled steel-tyres, no flanges being, of course, needed. There are two wheels at each end of the main girders on a wheel base of 13 ft. 6 in., measured on a chord at the radius of the outer bearing. The axles are of steel and rotate in roller bearings at each side of the wheel. The central pivot, which is shown in detail in Fig. 3, consists of a heavy steel casting carrying a single row of ball bearings. The cap rotating on the bearings carries the bolts by which the table is suspended from it. Adjustment of these bolts enables a precise distribution, between the pivot and the pathway wheels, of the weight borne on the table to be made. The pit walls are provided, at one or more positions on the circumference, with girders of fabricated steel construction, which carry the end chairs of the running-on rails. A pair of these rails is seen at the bottom left-hand corner of Fig. 5, the turntable being shown slewed round from the running-on position in this view. Correct alignment between the table rails and the running-on rails is ensured by a manually-operated bolt at each end of the table, the bolts engaging with holes in the running-on girders when the table is to be locked for taking on or running off a locomotive.

The rotation of a power-operated turntable should be effected from the locomotive itself, since an external source of power would require to be available at any hour of the day or night, a condition neither generally economical nor desirable. In the turntable now described, the motive power is derived from the atmosphere by creating a vacuum on the "exhaust" side of an oscillating engine. This engine, which is clearly shown in Fig. 6, page 624, has a pair of oscillating double-acting cylinders, each of 4½ in. bore by 6 in. stroke. The piston rods are attached to the pins of balanced disc-cranks, the crankshaft being carried in a pair of bearings between which is a pinion meshing with a spur wheel on a second motion shaft, which is finally geared to a spur ring attached to one of the pathway wheels. There are, naturally, no valves on the cylinders, admission and exhaust being effected by the automatic opening and closing of ports as the cylinders oscillate, but there are four valves in the chamber seen between the cylinders and means of these valves the reversal of the crankshaft rotation is effected. The chamber is divided into two compartments, connected, respectively, to the top and bottom ports of both cylinders, and having two valves controlling the admission of atmospheric air and the withdrawal of air by ejector-created vacuum. Clearly, by opening one of the valves in each compartment and closing the other, the conditions on either side of the pistons can be reversed, with a consequent reversal of the direction of rotation of the engine.

The vacuum, as may have been already inferred, is derived from the vacuum-brake system of the locomotive on the turntable, the operation of the table being as follows: The locomotive having been run on to the table, the fireman dismounts and couples the flexible hose seen in Fig. 6, to the train pipe, which may be either on the locomotive or on its tender. The position of this pipe and the situation of the atmospheric engine on the table is indicated at *a* in Fig. 4, the hand turning gear being indicated at *b* and the locking lever at *c*. The fireman takes up a position at these controls and operates lever *c* to withdraw the locking bolts. The engine-driver, who remains on the locomotive, then operates the vacuum brake ejector and the atmospheric engine is started by the fireman, who manipulates a single control lever to cause the engine to rotate so that the table swings round in a clockwise or anti-clockwise direction, as desired. When the running-off position is reached, the engine is stopped, the locking bolts engaged and the ejectors shut off, the final operation being that of uncoupling the hose. The table can thus be turned without effort on the part of the engine crew through 180 deg., in less than two minutes. The degree of vacuum required to operate the atmospheric engine is about 20 in. Hg.

As the reversing and speed control through the four valves is actuated by a single lever, the table is very readily stopped in the desired position while, in addition, a "dead-man" characteristic is, in effect, provided, run-away movements being thus impossible. The hand turning gear *b* is seen behind the open hinged cover of the atmospheric engine in Fig. 6. It consists of a column with two winch handles, which operate, through spur and bevel gearing, the pinion meshing with the spur ring on the pathway wheel. The hand gear is provided with a dog-clutch, visible in Fig. 6, by which it can be engaged or disengaged as necessary. Normal operation of the table is effected by power, as already described, but occasionally it may be desired to turn it when unloaded, or it may be that, for some reason, a vacuum may not be available. In such cases the hand winch is employed, this gear being so designed that the fully-loaded table, carrying 175 tons, can be turned by one man. The clutch lever is interlocked with the atmospheric engine control lever in such a manner that the clutch cannot be moved so as to engage the hand turning gear while the vacuum system is being exhausted. The locking bolts are indicated at *e* in Fig. 1, from which it will be seen that both are simultaneously controlled by the lever *c*, by means of a wire-rope system having adjusting turnbuckles. The push bars indicated at *f* in Figs. 1 and 4, are provided for emergency use, in case of breakdown of the other two turning systems. Normally, they are retracted as seen in Fig. 5. We understand from Mr. W. A. Stanier, Chief Mechanical Engineer of the L.M.S. Railway, to whom we are indebted for the above particulars, that several turntables of the articulated type have been installed and that replacement of the older types is still proceeding.

BOOKS RECEIVED.

Steel Manufacture Simply Explained. By E. N. SIMONS and DR. EDWIN GREGORY. London: Sir Isaac Pitman and Sons, Ltd. [Price 6*s.* net.]

Hoisting Machinery. Comprising Cranes, Derricks, Grabs, Skip Hoists, Stackers, Telphers and Transporters. By W. H. ATHERTON. London: The Technical Press Limited. [Price 32*s.* 6*d.*]

Electric Model Railways. From Mains to Trains. By E. F. CARTER. London: Percival Marshall and Co., Ltd. [Price 2*s.* net.]

1,001 *Mechanical Facts Made Easy. A Handbook of Simple Mechanical Knowledge.* Edited by PERCIVAL MARSHALL. London: Percival Marshall and Co., Ltd. [Price 3*s.* 6*d.* net.]

Government of Transjordan. Report on the Water Resources of Transjordan and Their Development. By M. G. IONIDES. *Incorporating a Report on Geology, Soils and Minerals, and Hydro-Geological Correlations.* By G. S. BLAKE. London: The Crown Agents for the Colonies. [Price 30*s.*]

A New Dictionary of Chemistry. Edited by DR. STEPHEN MIALL. London: Longmans, Green and Co., Ltd. [Price 42*s.* net.]

Mechanism and the Kinematics of Machines. By W. STEEDS. London: Longmans, Green and Co., Ltd. [Price 18*s.* net.]

United States National Bureau of Standards. Building Materials and Structures. Report BMS 37. *Structural Properties of "Palisade Homes" Constructions for Walls, Partitions and Floors. Sponsored by Palisade Homes.* By H. L. WHITTEMORE and A. H. STANG, with the collaboration of T. R. C. WILSON. [Price 10 cents.] Report BMS 43. *Performance Test of Floor Coverings for Use in Low-Cost Housing.* Part 2. By P. A. SIGLER and E. A. KOERNER. [Price 10 cents.] Washington: Superintendent of Documents.

Kingzett's Chemical Encyclopædia. A Digest of Chemistry and Its Industrial Applications. Revised and edited by DR. R. K. STRONG. Sixth edition. London: Baillière, Tindall and Cox, 7 and 8, Henrietta-street, W.C.2. [Price 45*s.* net.]

Department of Scientific and Industrial Research. Building Research. Wartime Building Bulletin No. 1. *Economic Type Designs in Structural Steelwork for Single Storey Factories.* [Price 1*s.* net.] Wartime Building Bulletin No. 2. *The Application of Reinforced Concrete to Wartime Building.* [Price 6*d.* net.] London: H.M. Stationery Office.

The Oil and Petroleum Year Book for 1940. *A Record of Companies Interested in the Oil Industry.* Compiled by W. E. SKINNER. London: Walter E. Skinner, 15, Dowgate-hill, Cannon-street, E.C.4. [Price 10*s.* net.]

The Alloys of Iron and Chromium. Volume II. *High-Chromium Alloys.* By A. B. KINZEL and RUSSELL FRANKS. London: McGraw-Hill Publishing Co., Ltd. [Price 40*s.*]

United States Bureau of Labor Statistics. Serial No. R.1067. *Hourly Earnings in Dyeing and Finishing of Cotton, Rayon and Silk.* Serial No. R.1078. *Wages, Hours and Working Conditions of Union Street-Railway Employees, June* 1, 1939. Washington: Superintendent of Documents.

Elements of Sanitation. Edited by E. S. HOPKINS. London: Chapman and Hall, Limited. [Price 21*s.* net.]

PERSONAL.

MR. H. J. ALLCOCK and MR. S. W. MELSOM have been elected chairman and vice-chairman, respectively, of the Transmission Section of the Institution of Electrical Engineers for the 1940-41 session.

MR. S. B. HASLAM has been elected president of the Association of Mining Electrical Engineers.

SIR HARRY BROWN, the former Director-General of Posts and Telegraphs in Australia, has been appointed Federal Co-ordinator of Works for the Commonwealth Loan Council.

MR. F. S. SPRIGGS, President of the Society of British Aircraft Constructors, has been made an honorary Fellow of the Royal Aeronautical Society.

PROFESSOR A. M. PORTEVIN has been elected an honorary member of the Institute of Metals.

MR. C. G. WILLIAMS, Director of Research of the Automobile Research Committee of the Institution of Automobile Engineers, has accepted an appointment with another research organisation in September, and DR. E. GIFFEN, of King's College, London, has been appointed his successor.

MR. W. A. TOOKEY, M.Inst.C.E., M.I.Mech.E., M.I.A.E., requests us to announce that all communications should now be addressed to 83, Cumberland-road, Bromley, Kent, and not, as formerly, to 36, Victoria-street, London, S.W.1.

MR. E. LANCASTER BURNE, A.M.Inst.C.E., M.I.Mech.E., has removed his office to 11, Great Ormond-street, Holborn, London, W.C.1.

PROFESSOR W. L. BRAGG, F.R.S., has been elected President of the Institute of Physics and will take office on October 1.

SIR GEORGE HIGGINS, C.B.E., has been re-elected Chairman of Lloyd's Register of Shipping, 71, Fenchurch-street, London, E.C.3, for the ensuing year. MR. E. L. JACOBS has been re-elected deputy chairman and treasurer, and MR. R. M. K. TURNBULL and MR. ROBERT CORRY, joint chairmen of the Sub-Committee of Classification.

LT.-COL. J. T. C. MOORE-BRABAZON has been appointed chairman of Messrs. Briggs Motor Bodies, Limited, Chequers-lane, Dagenham, Essex, in succession to the EARL OF GRANARD.

MESSRS. BROADWAY ENGINEERING COMPANY, LIMITED, Carlisle-road, Hendon, London, N.W.9, have been appointed sole agents for Messrs. Machinery Manufacturing Company, Los Angeles, California, U.S.A.

MR. ARNOLD WALTERS has been appointed representative, in Scotland, of Messrs. Newton, Chambers and Company, Limited, Thorncliffe Ironworks, near Sheffield, for blast-furnace and steelworks plant. He is succeeding MR. JAMES TAYLOR, 102, Bath-street, Glasgow, who has retired.

MESSRS. C. H. MOUNTFORD, 68, Nechells Park-road, Birmingham, 7, have been appointed the sole Midland agents and representatives of Messrs. Taylor Stoker Company, Limited, 25, Russell-square, London, W.C.1, manufacturers of the Taylor "Lo-Hed" hoists.

MR. G. H. NISBETT, who has been an executive officer of Messrs. British Insulated Cables, Limited, for forty-six years, has relinquished his duties as managing director. He will continue to act as deputy-chairman.

TENDERS.

WE have received from the Department of Overseas Trade, Great George-street, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

Electrical Equipment for reconstruction of electricity undertaking, including switchgear, transformers, cable, and joint boxes. Municipality of Umtali, South Africa; July 26. (T. 20,472/40.)

Electrical Equipment. With reference to the call for tenders for high-speed circuit breakers, isolating links and other electrical equipment, noted on page 562, *ante*, we now learn that the South African Railways and Harbours have postponed the closing date from July 17 until August 6. (T. 19,785/40.)

House-Service Cut-outs. City Council, Johannesburg; July 13. (T.Y. 20,539/40.)

Domestic Electrical Equipment, comprising washing machines, water heaters, cookers and refrigerators. City Council, Johannesburg; July 13. (T. 20,543/40.)

Coir Rope, circumferences ranging from 2½ in. to 18 in. South African Railways and Harbours, Johannesburg: August 23. (T. 20,544/40.)

Road Plant and Waterworks Equipment. With regard to the call for tenders for road plant and waterworks equipment for new schemes, noted on page 582, *ante*, we now learn that the Town Engineer, Beaufort West, South Africa, has postponed the closing date from June 24 until July 22. (T. 19,829/40.)

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—The decision of the French Government to cease hostilities resulted in the official suspension of shipments of coal to France, which has always been South Wales' largest individual customer for coals. In the last year for which official figures were available, 1938, France took just over 4,400,000 tons, compared with a little under 6,100,000 tons in 1937. Since the outbreak of the war, France has been making increasing demands upon local shippers, who have made every effort to maintain deliveries to this market. It was partly to meet France's war needs that steps were taken to expand the coal output. Following the suspension of deliveries to France, supplies of coal for early shipment became more readily available on the steam-coal market than had been the case for a long time. Consequently, it is confidently anticipated that exporters will now be able to take full advantage of the business available in other countries. It was officially announced by both the miners' and owners' representatives during the week, that there was no reason for any relaxation in the efforts being made to increase production. Following the recommendation of the coalfield conference, the men have instituted a coal-producing shift on Sunday nights at all collieries in the coalfield at which it was practicable. Despite the fact that supplies of all descriptions were more readily available on the market, sellers were showing the greatest reserve and the general tone was consequently firmly maintained. There was a sustained demand from inland users for cokes, but the tone was firm. Patent-fuel manufacturers were busily engaged and a steady tone ruled.

The Iron and Steel Trade.—Activities in the iron and steel and allied industries of South Wales and Monmouthshire were well maintained during the past week. There was a keen request for the various finished products and, with order books well filled, most works were engaged practically to full capacity.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The last two months have witnessed a large increase in the output of steel and engineering products generally in the Sheffield district, the current output being substantially greater than the peak reached during the last war. Sheffield Corporation is making special arrangements to collect scrap metal of all types, and although a large tonnage was collected last month, the figure is expected to be exceeded during the current month. The demand for raw and semi-finished materials continues to increase. Greatly extended batteries of furnaces are operating continuously and are turning out record tonnages. The requirements of pig iron and hematites are obtained without difficulty. Re-rollers are busily employed, and structural steel is in strong demand. A large number of overseas inquiries for a variety of equipment and machinery are circulating in the heavy-machinery and engineering branches. The call for increased outputs by the Government has resulted in many works formulating plans for extensions to their productive capacities. The manufacture of large hollow forgings and boiler drums is making satisfactory progress. These are on order for power-station extension schemes. Orders for heavy grinding and crushing machinery are reported to be less plentiful on export account. The medium branches are employed to their full capacity, and the tool trades are operating at high pressure.

South Yorkshire Coal Trade.—Outputs at all the pits in this area show an increase. Industrial concerns are taking record tonnages of coal, and stocks are being accumulated at many works. Railway companies are in the market for large quantities of locomotive fuel. Householders are buying now for their winter requirements. The coke market is satisfactory.

THE LATE MR. A. H. CARNT.—We note with regret the death of Mr. Alan Hubert Carnt, which took place as a result of a motor-car accident on the North-road on June 13. Mr. Carnt, who was a director of Messrs. Peter Brotherhood, Limited, Peterborough, was 45 years of age. He was the only son of Commander A. J. Carnt, of Walton, and was educated at Blackheath Preparatory School and at Oundle. In 1912 he entered Messrs. Brotherhood's works, but on the outbreak of war in 1914 he joined the army and was given a commission in the Royal Engineers. He later transferred into the Royal Flying Corps, and as the result of a crash was invalided home, but, on recovery, returned to the Royal Engineers. Subsequently, he joined the Royal Tank Corps, in which he was serving at the conclusion of hostilities. He was appointed a director of Messrs. Brotherhood in 1931 and for the last few years had been in charge of the firm's refrigeration department.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The aggregate tonnage output of iron and steel is at a record level, but provides little tonnage for ordinary purposes, national requirements absorbing the bulk of the production. Much of the plant is operating at full capacity. At certain works the necessary renewals of machinery are proceeding expeditiously and the production of material promises to be increased still further.

Cleveland Iron Trade.—Very little Cleveland pig is now obtainable, but foundry-iron users are still receiving adequate supplies from the Midlands. Prospects of a resumption of a regular make of Cleveland pig are as remote as ever.

Hematite.—Producers of East Coast hematite contrive to cover the heavy and expanding requirements of consumers but are unwilling to add to their extensive commitments until a material improvement in the statistical position is assured. To meet the increasing demand, an early addition to the make is essential, and a movement to achieve a satisfactory handling of the situation is proceeding. Consuming works owned by hematite producers continue to take up most of the blast-furnace output, but other delivery obligations are extensive. Customers who are well bought are insisting on full contract deliveries and are endeavouring to make forward purchases.

Basic Iron.—Basic-iron makers continue to use the whole of their output at their adjacent steelworks.

Foreign Ore.—Consumers of foreign ore have ample supplies for current needs and imports are quite up to expectation. While the forward position is not clear, the sources of supply are still considerable.

Blast-Furnace Coke.—The supply of Durham blast-furnace coke are plentiful, but sales are few. Local users are well covered and sellers are disinclined to add to their commitments.

Manufactured Iron and Steel.—Imports of American semi-finished iron and steel, particularly the latter, are enabling re-rollers to keep their mills actively employed. The home make of steel semies has also been augmented; finished-iron firms are gradually increasing production. Engineering constructional schemes, shipbuilding requirements, and other work are taking a large proportion of the output of finished-steel works.

Scrap.—Certain kinds of iron scrap are in fairly good supply, but larger deliveries of steel scrap are still required.

SMALL-TOOL BALANCING DEVICE.—The extending use of small electric and pneumatic tools has resulted in the development of a spring-operated suspending device for balancing their weight. The larger tools of this class have been thus catered for for some time, an illustrated account of such a device having been given in ENGINEERING, vol. 121, page 644 (1926). The new appliance, which is known as the "Midget" Balancer, is for the suspension of any portable tool, jig or fixture weighing up to 8 lb., and is made by Messrs. The Consolidated Pneumatic Tool Company, Limited, 232, Dawes-road, London, S.W.6. It is designed on the same general principles as the larger balancer made by the same firm, and referred to above, but the adjustment of the spring tension is somewhat simpler. The use of the balancer greatly adds to the efficiency of the operator by reducing fatigue and saving the time required for adjustment of the chain blocks, etc.

EXPORTERS' RISKS IN WAR TIME.—The Export Credits Guarantee Department, 9, Clements-lane, Lombard-street, London, E.C.4, has announced an important extension of the facilities provided for insuring exporters against the risks of export trade in war time. The Department is now prepared to cover exporters against risks of their being unable to effect shipment of goods under export orders by reason of (*a*) the insolvency of the buyer before shipment is due to take place; (*b*) the imposition of import restrictions in a buyer's country, after an order has been placed; and (*c*) the occurrence of war, invasion, civil commotion and the like. Two forms of policy will be issued, available, respectively, to holders of the Department's Comprehensive Guarantee and other traders. The policy in either case covers an exporter's entire trade and 75 per cent. of the loss is covered on very favourable terms. The Department's guarantees against insolvencies overseas, the transfer risk and the pre-shipment risk when combined with the customary commercial insurance (such as marine) give an exporter a wide measure of protection against his principal trading risks from the time of booking an export order to the final receipt of payment.

NOTICE OF MEETING.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF CIVIL ENGINEERS.—*North Western Association:* Wednesday, July 3, 6.30 p.m., The College of Technology, Manchester. Lecture: "Recent Developments in Air Raid Precautions," by Mr. R. E. Bowles.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—In the Scottish steel trade arrangements are being made still further to improve on the recent record output figures, and the men are responding loyally. The production of steel has been maintained during the past week on a very high level, but little is being freed for other than essential purposes. The shipyards are actively employed and are consuming a very large tonnage of plates, sections, etc., and the demand from other buyers is also extremely heavy. There is a heavy demand for light steel plates and sheets, and makers are all working at high pressure to overtake urgent orders. Drums and containers of all kinds are being turned out in large numbers, and all establishments are working to their full capacity. The raw material position is satisfactory. The following are the current prices:—Boiler plates, 13*l.* 8*s.* per ton; ship plates, 12*l.* 10*s.* 6*d.* per ton; sections, 12*l.* 8*s.* per ton; medium plates, $\frac{5}{16}$ in. thick, weighing 6 lb. or more per square foot, 14*l.* per ton, and weighing under 6 lb. but not less than 4·81 lb. per square foot, 14*l.* 10*s.* per ton; black-steel sheets, No. 24 gauge, in 4-ton lots, 17*l.* 10*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, in 4-ton lots, 20*l.* per ton, all delivered at Glasgow stations.

Malleable-Iron Trade.—No change has taken place in the malleable-iron trade of the West of Scotland, and the works are fully occupied. The re-rollers of steel bars have so much work on hand that whenever possible production is continued on a seven-day week basis. The supply of semi-manufactured steel is sufficient to ensure continuous running for the present, and forward deliveries have already been negotiated. Prices are steady and are as follows:—Crown bars, 14*l.* 2*s.* 6*d.* per ton; No. 3 bars, 12*l.* 10*s.* per ton; No. 4 bars, 12*l.* 15*s.* per ton; and re-rolled steel bars (tested), in 4-ton lots, 14*l.* 3*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—Active conditions continue to prevail in the Scottish pig-iron trade and the present output is on a much higher scale than it has been for some time past. Every effort is being made to keep the blast-furnaces running at full capacity. Deliveries are being made rapidly and stocks are not being allowed to accumulate. The following are the current market prices:—Hematite, 6*l.* 7*s.* 6*d.* per ton, and basic iron, 5*l.* 4*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 5*l.* 15*s.* per ton, and No. 3, 5*l.* 12*s.* 6*d.* per ton, both on trucks at makers' yards.

LAND-DRAINAGE SCHEMES.—A circular issued by the London Chamber of Commerce states that the period in which grants are available towards the cost of land-drainage schemes in England and Wales has been extended by the Minister of Agriculture and Fisheries, with the consent of Parliament, until July 31, 1941.

EXPORT LEAFLETS OF FLOUR-MILLING AND FOOD-PREPARATION MACHINES.—Messrs. E. R. and F. Turner, Limited, milling engineers, Foxhall Works, Ipswich, have issued a folding leaflet containing 90 reproductions of photographs, and brief descriptions of their complete range of washing and conditioning, dry-cleaning, sifting, grinding and milling machines, purifiers, dust collectors, and flaking, breakfast-food and other plant and machinery and accessories. Identical leaflets, printed in French, Portuguese, Spanish and German, have also been issued and these should greatly facilitate relations with overseas buyers.

COLLECTION OF WASTE MATERIAL ON L.M.S. RAILWAY IN LONDON.—Three specially-adapted railway vans are touring 100 London Midland and Scottish Railway stations in the London area to collect war-time salvage. By this and other means, 100 tons of salvage, including scrap metal, waste paper, old rope, straw and timber, have been collected since the scheme was put in hand. The vans operate on circuits ranging from three to six days each and are taken from station to station by ordinary trains, so that the expense of collection is negligible. All the scrap and waste material collected by the vans is taken to a central depot in North London, where it is sorted and afterwards disposed of to the best advantage.

70-FT. ARTICULATED LOCOMOTIVE TURNTABLE FOR L. M. S. RAILWAY.

MESSRS. COWANS, SHELDON AND COMPANY, LIMITED (ENGINEERS), CARLISLE.

(*For Description see page* 621.)

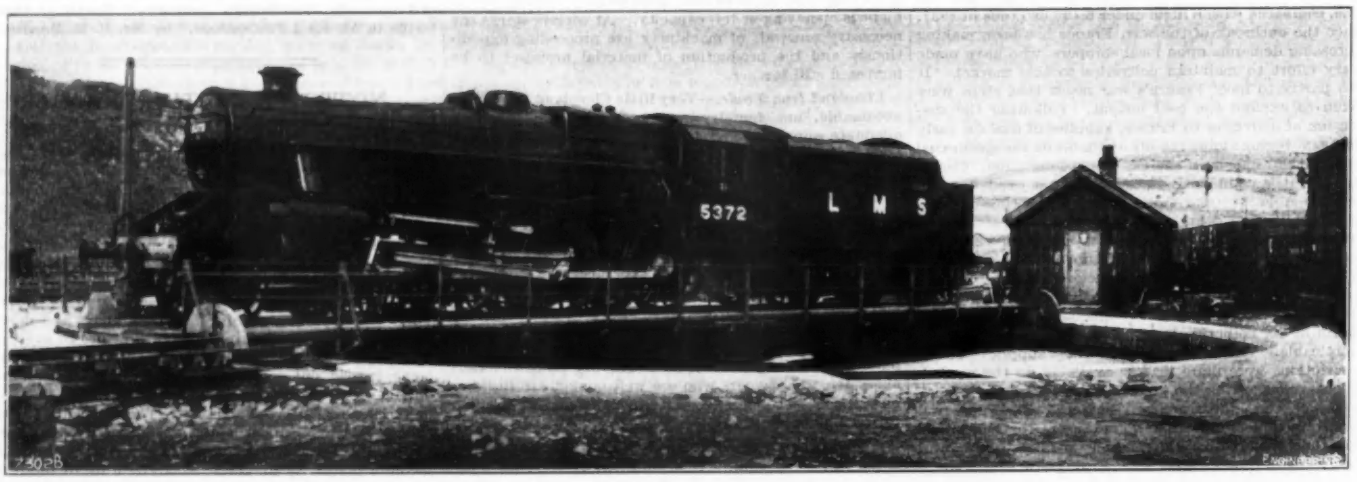


FIG. 5. LOADED TURNTABLE SLEWED FROM RUNNING-ON POSITION.

NEW HIGH-VOLTAGE LABORATORY OF THE BUREAU OF STANDARDS.

A SHORT account of the new high-voltage laboratory which has recently been completed for the National Bureau of Standards in Washington, is given by Mr. F. B. Silsbee in the June issue of *Electrical Engineering*. This laboratory will enable the four classes of work undertaken by the laboratory, namely, X-ray and nuclear physics studies, the precise calibration of voltage transformers, the testing of insulating materials for the Federal Government, and research and development on methods of measurement at high voltages, to be carried out on a more extensive scale.

The new building consists mainly of a large room, 135 ft. long, 65 ft. wide, and 60 ft. high, in which the equipment for the higher voltages will be installed. Contiguous to this is a five-storey structure housing a number of smaller laboratories, in which apparatus for lower voltage work will be provided, as well as office accommodation and the control apparatus for the higher voltage equipments. The walls of the large room are lined with copper sheet, and the external walls are thermally insulated with a 3-in. layer of cork. The ceiling is of metal and steel armouring, which is bonded to the frame of the building, has been cast into the concrete floor. The conducting lining serves three purposes: It makes the bound charges induced on the walls by the pressure of electrically-charged conductors definite; it prevents interference with radio measurements in the other laboratories; and, finally, it renders the walls relatively tight against the infiltration of water vapour. The climate of Washington is so humid in summer that many types of electrical measurements are rendered impossible owing to surface leakage over the insulation. Special equipment is, therefore, provided for drying the air in the interior of the building. To protect the workers in the small laboratories from scattered X radiation, a 12-in. concrete wall has been erected between them and the main laboratory. All equipment which might produce noise or vibration has also been housed in a separate annexe.

The equipment for X-ray work includes a cascaded bank of ten units, each consisting of a transformer, rectifier and capacitor. These have a current rating of 25 milliamperes and are designed, when connected in series, to produce 1,400,000 volts direct-current of either polarity. They can be used to supply any one of three vacuum tubes, two of which are for X-rays, while the third is a source of neutrons. Other equipments giving 400,000 volts, 200,000 volts, and 10,000 volts are also available. The equipment employed for testing voltage transformers for ratio and phase angle is based primarily on the precision-shielded resistor now used at the Bureau. This is suitable for pressures up to 30 kV. In the past, two 10-kVA transformers rated at 100 kV have been used to step up the precision measurements over a range of 4 to 1 by changes in their high-voltage connections from parallel to series. In the new laboratory, a further 2 to 1 step-up is obtained by using a 100-kVA transformer with two high-voltage coils, which may be connected in series to give a pressure of 250 kV. The high-voltage attracted-disc electrometer will be installed in a room of which the temperature can be accurately controlled. This instrument has already been used up to 100 kV as an independent check on the ratio measurements, and in its new quarters, is suitable for pressures up to 300 kV. An additional independent means for measuring ratio and phase angle will be secured by the use of air capacitors, a number of which, it is anticipated, will be constructed in the near future. The first of these will be of the compressed-gas type for use up to 150 kV, while later a free-air capacitor for 250 kV will be installed. These capacitors will provide an additional independent means for measuring ratio and phase angle on voltage transformers and can also be used as standards for the measurement of dielectric loss in insulation.

The existing equipment for testing the dielectric strength of insulating materials and the flash-over voltages of insulating structures will be supplemented by three new 350-kV testing transformers, which can be connected in cascade to give 1,050 kV to earth at 60 cycles. An impulse generator with an energy rating of 33,000 Joules will also be installed, and will give a pressure of 2,000 kV when used with a Marx circuit. This equipment will be arranged so that it can also be used as a source of surge current at 100 kV.

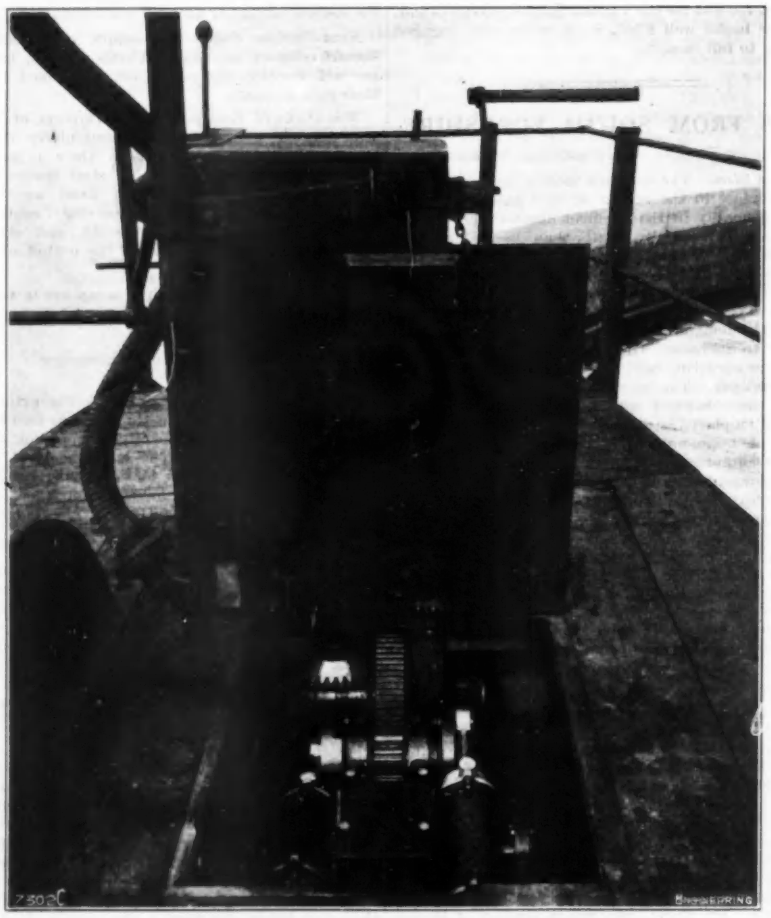


FIG. 6. OSCILLATING ENGINE FOR OPERATING TURNTABLE.

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

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ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines, or under, and one shilling per line up to one inch. The line averages six words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns, of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered no later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

CONTENTS.

	PAGE
Telegram-Form Conveying Systems; General Post Office.—IV (*Illus.*)	615
An Analysis of Certain Characteristics of a Kadenacy Engine (*Illus.*)	617
The "Impulsor" Emulsifier (*Illus.*)	621
70-Ft. Locomotive Turntable for the L.M.S. Railway (*Illus.*)	621
Books Received	622
Personal	622
Tenders	622
Notes from the South-West	623
Notes from South Yorkshire	623
Notes from Cleveland and the Northern Counties	623
Notice of Meeting	623
Notes from the North	623
New High Voltage Laboratory of the Bureau of Standards	624
Aiding Munitions Production	625
The National Physical Laboratory	626
Notes	627
The Theory of Meandering	628
Letter to the Editor.—The Late Professor Sir Thomas Hudson Beare	629
The Late Sir Jocelyn Thorpe	629
The Late Professor A. Fowler, C.B.E., F.R.S.	629
4-6-0 Type Passenger Locomotive for Jaipur State Railway (*Illus.*)	630
Protective Films on Tin-Plate	630
Labour Notes	630
Fuel Injection in Oil Engines in Relation to Combustion (*Illus.*)	631
Progress in Feed-Water Treatment	633
"ENGINEERING" Patent Record (*Illus.*)	634

Two One-Page Plates.—TELEGRAM-FORM CONVEYING SYSTEM; GENERAL POST OFFICE. 70-FT. ARTICULATED LOCOMOTIVE TURNTABLE FOR L.M.S. RAILWAY.

ENGINEERING

FRIDAY, JUNE 28, 1940.

VOL. 149. No. 3885.

AIDING MUNITIONS PRODUCTION.

ABRAHAM LINCOLN is usually credited with being the first to remark that he had had a heap of trouble in his time—"but most of it never happened." The correctness or otherwise of the attribution does not matter greatly at the moment, but the philosophy underlying it may be appropriately commended to those who have seen, in the defection of King Leopold, the intervention of Italy, and now the capitulation of the French Government (we refrain deliberately from writing "of France"), so many gloomy and distressful portents of the ultimate outcome of this present struggle. Of reason for complacency, for the persistence of what future historians may well come to describe as the "Maginot complex" which has cost France (and Britain) so dearly in the past few weeks, there is none whatever; but it is always advisable to remember that there are two sides to most questions, and that the conquest of Great Britain, from the enemy's viewpoint, must assuredly be a problem that is causing the German High Command very considerable searchings of mind.

It is encouraging to examine the position from the other side, bearing in mind that the very fact of the elimination from the contest of the armies fighting in France has greatly restricted the possible scope of an enemy intelligence service. All through the war of 1914-18, the Allies were being told that one main reason why their forces made such slow progress against the German forces was that the Germans possessed the great advantage of fighting from interior lines, within which they could move their troops freely to reinforce weak sectors. That advantage is now ours, and to a degree that Germany never enjoyed, as our sources of supply in the Empire and the United States are assured. In such circumstances, the problems confronting an attacking force are formidable in the extreme.

For some time yet to come, however, the full weight of overseas support cannot be brought to bear, and meanwhile the industry of this country is charged with a heavy task. Mr. Ernest Bevin, the Minister of Labour, and Lord Beaverbrook, Minister for Aircraft Production, have given clear indications that they have taken an accurate measure of their respective tasks, and direct observation confirms that their efforts and those of the organisations that they command are bearing good fruit. The losses of material involved in the withdrawal of the British Expeditionary Force from France, so soon after that from the Low Countries, are obviously great, but they are being made up at a gratifying rate, and the pace of production is still accelerating. Even so, however, it may be questioned whether the basic idea of a long-term plan of munitions production is not being pursued too religiously, to the exclusion of means and expedients which, while they might be difficult to fit into the framework of existing schemes, might still form useful auxiliaries to them.

As Mr. Bevin has indicated, not every man at present unemployed would be necessarily an asset if a niche could be made for him; but there does seem to be a curious reluctance, in some quarters, to make immediate use of personnel and methods which the experience of the previous war showed to be a valuable reserve. For example, very large quantities of munitions were produced, between 1915 and 1918, by voluntary labour, working in small repair shops and similar establishments. We have in mind one shell-turning plant, which began in a small way in the repair shop of a provincial tramway system. The paid personnel numbered less than half a dozen, drawn from the permanent staff of the tramway department, and they were responsible for the preparation and maintenance of the machines and the organisation of supplies of material. The whole of the machine operators were local residents, men and women of all ages from 16 to 60, who gave their services as and when they could. Sufficient volunteers were obtained, who were in a position to work four or five hours at more or less regular intervals, to ensure that a majority of the machines would be kept continuously at work, day and night. Many others were able to work only an hour or perhaps two at a time, and could not undertake regular attendance: they reported for duty when they could, operated a machine if a suitable one was available, or assisted in the general labouring or clerical work if nothing else offered.

To run a works successfully on such lines naturally calls for a considerable organising ability; but in this case the ability was there, and the output was so satisfactory, both in quantity and quality, that the local controller of machine-tool supplies diverted to the erstwhile tramway shop a number of machines intended for a national munitions factory, which was not quite ready to receive them. During the latter half of the war, we had an opportunity to pay an unofficial visit to the shop, and to watch the night shift at work. Men and women came and went, in their own cars, on bicycles, or on foot, as their other avocations permitted or required, all through the night; but the work never ceased. The machines were almost as varied in type as the operatives, but they were well maintained, and there was a sufficient leaven of technical skill, provided, for example, by amateur model-makers, bicycle repairers, and men who had served an engineering apprenticeship but had subsequently turned to other occupations, to ensure that they were treated with reasonable care. In this particular case, the principle of voluntary work was fully justified by results, and, although a much larger proportion of the possible reserve of personnel is engaged on civil-defence work in this war, the possibility of organising a chain of such establishments at the present time appears to deserve a more active investigation than it seems to have received.

The policy of utilising the resources of technical-school workshops to produce gauges and other small components is making satisfactory progress. We have received some complaints that offers of part-time service in such shops have been declined, for the reason that no arrangements had been made in particular localities to undertake productive work in the schools. It is easy to understand the dissatisfaction which such a reception can cause, but there is no reason to suppose that it will be of long duration. The amount of preliminary staff

work involved in organising the distribution of orders and of materials to a large number of small establishments is not always appreciated, and in view of the short period that has elapsed since the announcement that work of this kind would be allocated to the technical schools, the progress already made must be regarded as satisfactory. The contention that this step should have been taken a year ago is reasonable; but it does not appear that there has been any avoidable delay in implementing the decision, now that it has been made, and, in the interim, the school workshops have been usefully employed in their primary purpose of affording engineering training.

If excuses can be made, however, for apparent failure to turn such establishments on to munitions production immediately on the outbreak of war, it is difficult to see adequate reasons for the persistent refusal to take advantage of certain other sources of valuable technical skill. In many cases, the reason seems to be nothing more substantial than the arbitrary application of a rigid limit of age beyond which it is apparently assumed that no useful service can be expected. The question of remuneration is a contributory though not a major problem, in many cases; but the sore point is the inability to secure any useful work or even an opportunity to establish a claim for consideration. Centralisation is admirable in theory and presents undoubted advantages in practice, in appropriate circumstances; but the disadvantages are not negligible, and the difficulty of accommodating a system, originally designed to deal with manual labour, to so individualistic a range of occupations as is represented by professional engineering, is one which should have been foreseen. The officials of the Central Register may not regard as of much importance the circumstance that so many of the registration cards returned through the engineering institutions bear the classification numbers of general categories—the use of which, the instructions state, "should be avoided if possible"; but it is a pointed commentary on the system itself that so many men, trained in the habit of exactitude, should find such difficulty in defining their own categories. The schedule of classifications is, in fact, eminently suited to the sorting and grading of men who have got into grooves at an early age and have been content to remain there, but it is a handicap to the men of wide and varied experience; yet these are the more likely to adapt themselves quickly and effectively to novel conditions and to display initiative in an emergency.

If these remarks appear somewhat cursory, it is because they attempt to present at once the substance of a variety of personal views that have been brought to our notice by letters, in conversation, and as a result of direct observation. One feature that the original communications have in common, almost without exception, is their completely unselfish outlook; the complaints are not that the individual has been deprived of the opportunity of pecuniary gain, but that there must be some serious defect in a system which places so many obstacles in the way of people who want to do useful work and who, not solely on their own showing, appear to be capable of doing it.

THE NATIONAL PHYSICAL LABORATORY.

THE Annual Report* of the National Physical Laboratory for 1939 reveals that, although the outbreak of war has led to a considerable expansion of the work carried out on behalf of the Service and Civil Defence Departments, and to some redistribution of the staff to cope with the war-time problems encountered in industry, it has been found desirable to continue many of the major researches in progress prior to the war and to maintain at a high level all the standards of physical measurement for which the Laboratory is responsible. Since most of the special problems arising from the war are confidential, the somewhat brief accounts of the Laboratory's work, given in the Report, deal mainly with long-term researches, many of which have been advanced to important extents, especially in cases where progress results can serve, even partially, the immediate purposes of industry.

Engineering.—In the Engineering Department, for example, an investigation of the mechanical properties of plastics is being carried out, chiefly with the object of using these materials in aircraft construction. The results obtained will, of course, also be valuable in the more general engineering and architectural applications of plastics, and in this connection one branch of the investigation is specially directed to developing a satisfactory method of measuring the surface hardness of moulded plastics, such as synthetic-resin bonded board, and filled synthetic-resin and casein products, which take a fine surface finish. A development in the study of fatigue of metals is the design of a rotating-bending machine to test specimens up to 2 in. in diameter. This machine is to be used, first, to investigate scale effects in fatigue phenomena, and subsequently to examine industrial engineering components incorporating stress-concentrating features for which specimens of large size are required. Similar work, under combined bending and torsional fatigue, has been carried out during the year on circumferentially notched specimens of seven different steels, for which stress-concentration factors have been found to vary from 1·5 to 2·4 in pure bending, and from 1·2 to 1·8 in pure torsion, with intermediate values for combinations of the two forms of stressing. Tests, in a rotating-strut machine,* on wires subjected to various grinding, polishing, and heat treatments, have revealed that successive reductions in diameter do not continuously increase fatigue resistance, and that cyanide heat-treatment can give practically the full intrinsic fatigue resistance without surface grinding or polishing. In connection with the use of welded construction for large pressure vessels, intended for the transport of liquefied gases, fatigue tests under direct tensile loading at right angles to the direction of the weld have indicated that the fatigue limits of normalised water-gas forged welds range from 12 tons to 15 tons per square inch; and of normalised electric-arc welds range up to 14 tons per square inch; as compared with 16 tons per square inch for the ¾-in. mild-steel boiler plate in which the joints were made. As regards small cylinders for transport of compressed gases, tests and examinations have been continued on cylinders of manganese (1·3 per cent. to 1·7 per cent.) steel, to the stage that recommendations as to the use of this material have been made to the Home Office through the Gas Cylinders and Containers Committee.

Among the more fundamental engineering researches, further X-ray studies of the deformation and fracture of metals have revealed important differences in behaviour between aluminium in the single-crystal and polycrystalline conditions. The creep behaviour of a 0·17-per cent. carbon steel at 455 deg. C. has been investigated under combined tensile and torsional stresses, attention being given to the factors which influence creep recovery. In the related subject of pipe flange performance, experiments under steam pressures of 1,200 lb. per square inch and 2,000 lb. per square inch have advanced this work beyond the stage reached in the second report† to the Institution of Mechanical Engineers. Lubrication research includes an investigation of the comparative values of animal, vegetable and mineral oils, with special reference to the reduction of friction and the prevention or delay of breakdown under conditions in the transition from boundary to fluid-film lubrication. Other work of the Engineering Department deals with stiffened sheet-metal construction and motor-cycle silencing, while a variety of tests for industrial bodies include ventilation, vibration and heat insulation problems.

Metallurgy.—With the dissolution, in 1939, of the Metallurgy Research Board of the Department of Scientific and Industrial Research, the responsibility for the programme of the Metallurgy Department now rests on the Executive Committee of the Laboratory. With the help of the Alloys Subcommittee of the Aeronautical Research Committee, researches have been conducted on the ageing of copper-aluminium alloys and on the improvement, by forging treatment, of the mechanical properties of magnesium alloys. High-purity iron, containing from 0·001 per cent. to 0·006 per cent. impurities, has had its melting point measured to be 1,533 ± 5 deg. C., and has been used for the determination of the iron-nickel constitutional diagram in the neighbourhood of the delta phase. Work on the temperatures of transformation of steels have revealed interesting differences, attributed to segregation, between the behaviour of a rimming steel and a solid steel, while variation in the rates of transformation are believed to account for the effect of adding 0·4 per cent. molybdenum to nickel-chromium steel. A comprehensive paper on steels suitable for high temperature steel plant has been published,* and further work on the effects of carbon (up to 1·2 per cent.) in steel for use at temperatures from 350 deg. to 950 deg. C. is approaching completion. Other metallurgical research has dealt with the intercrystalline failure of copper-zinc-aluminium alloys, high-temperature refractories, and porcelain and glassware for laboratory use.

Metrology.—An enormous increase in the testing and calibration of instruments and measuring appliances occupied an augmented metrological staff, during the latter half of last year, to the exclusion of all but the maintenance of essential standards. Marked increases over the previous year also occurred in the quantity of volumetric glassware and hydrometers tested. In the early part of the year, however, some progress was made in the determinations of the refraction and dispersion of air over the ultra-violet and infra-red regions of the spectrum. Special work, the value of which is now being realised, was carried out on the design of appliances for the inspection of splines and spline gauges. These instruments, which have a precision of about 0·00002 in., are now being manufactured for use in the aero-engine industry. Highly-accurate density determinations have been made on a new primary standard pound weight, of platinum-iridium alloy, which is being constructed for the New Zealand Government; while ordinary calibrations of barometers, watches, chronometers and taximeters have been carried out as usual.

Aerodynamics.—Substantial progress is reported in the installation of four new wind tunnels and the whirling arm, the last being now modified in design so that only the extremity of the arm which carries the test model projects beyond a central circular enclosure, this reducing undesirable air swirl. In compressed-air tunnel tests of large-chord metal aerofoils, the point of transition from laminar to turbulent flow has been detected from the effects on drag (measured by the Pitot-traverse technique) of a fine wire arranged near the aerofoil surface, parallel to the span, at varying distances from the leading edge. Extensive work on landing flaps, especially of the split and slotted types, has revealed a generally favourable scale effect, the maximum lift increasing considerably as the Reynolds number rises from 3,000,000 to 5,000,000. Recently developed devices to give greater lifts than simple flaps are now being similarly investigated. The interference drag of a wing-nacelle-airscrew combination has been studied, and several new aircraft designs have been tested with special reference to slipstream effects. Other interference research has dealt with the effects of airscrew-wing combinations, of the proximity of the ground on monoplanes, and of the slipstreams of two-engined machines on stability and control. Renewed attention has also been given to the stability of kite balloons and kites, while theoretical and experimental work on wing flutter has been directed, not only to the normal incidence range of flight, but also to pitching oscillations passing through the stall or lying entirely within the stalled regions of incidence.

Fundamental work on fluid motion includes studies of the boundary-layer characteristics of bodies immersed in a water tunnel, and has revealed that spasmodic-swirl is always present near the entry to a pipe unless a straightener or honeycomb

* *The National Physical Laboratory Report for the Year 1939.* H.M. Stationery Office. [Price 2*s.* 6*d.* net.]

* ENGINEERING, vol. 140, page 45 (1935).

† *Proc. I.Mech.E.*, vol. 141, page 433 (1939).

* Report J/T 116 of the B.E.A.I.R.A., *Proc. I.Mech.E.* vol. 141, page 271 (1939).

is fitted. Such swirl leads to inconsistent and inaccurate results in flow measurements made by a vane anemometer near the entry to a duct. The hemispherical-headed standard Pitot-static tube has been calibrated up to an air speed of 200 ft. per second, the factor being unity within 0·5 per cent. at the highest speed. A research of particular interest to engineers, from which the wind effects on most forms of lattice-girder bridge construction can be estimated, has been completed.

Ship Testing.—The volume of routine performance-testing for shipbuilders was large during the early part of last year but has decreased since the outbreak of war, enabling research work to be done on the effects of propeller characteristics upon ship performance and propulsive coefficient. An investigation of level and spread in relation to the efficiency of twin-screw performance has been completed, while some progress has been made in studies of propeller vibration, fouling of ships' hulls, and the wave resistance of three-dimensional ship forms.

Heat.—A new fixed point on the International Temperature Scale has been provided by a determination of the boiling point (648·8 ± 0·1 deg. C.) of selenium. Work of industrial interest includes measurements of the thermal constants of light alloys used in aero-engine manufacture, and developments in methods of measuring the temperatures of very hot liquids.

Radiology.—X-ray studies of the structure, fatigue and mechanical properties of metals have now reached a stage where it is possible to classify structural changes in relation to the associated conditions of stress, and to conclude that the expansion of the atomic lattice of certain non-ferrous materials, caused by cold work, corresponds to a latent internal stress of the same order as the breaking strength of the metal.

Sound.—Acoustic investigations with particular engineering applications have been concerned with air-raid warning devices, the reduction of noise in tube trains, the vibrations of "singing" propellers, and the silencing of motor cycles, among the latter being a type, submitted for study by the Mechanisation Board, for which substantial noise reduction has been achieved by an improved form of exhaust silencer. Experiments on noise in buildings have demonstrated the merits of floor treatments in reducing impact noise, and of a double party wall between semi-detached houses as a means of insulation against impact and air-borne sounds.

Light.—Optical and photometric research, recently combined within a new Department of Light under the superintendence of Mr. T. Smith, F.R.S., formerly principal scientific officer in the Physics Department, has been much engaged, as a consequence of the "black-out" regulations, with problems such as the transmission of light through textile materials, the screening of lighting fittings, and the measurement of very low intensities of illumination. Nevertheless, studies of radiation, lenses, and colorimetry have made some progress, and an optical instrument for appraising metal-surface finishes has been extensively tested.

Electricity.—As noted in our issue of April 19 last (page 412), Dr. E. H. Rayner, who recently retired under the age limit, has been succeeded as superintendent by Mr. R. S. J. Spilsbury, previously a principal scientific officer in the Electricity Department. Much work has been devoted to testing substandard apparatus for electricity supply authorities, and in perfecting methods of high-precision measurements required in the communications industry. The electrical properties of plastic materials, including laminated boards, have been further examined, while research has continued upon insulators, dielectrics and protective devices for high-voltage systems.

Radio.—The main objectives of the Radio Department are the production and propagation of ultra-short waves, the improvement of direction-finding with waves down to about 2 m., the study of the ionosphere, and the modes of propagation of radio waves. The development of apparatus and measuring instruments for such work, no less than the results of the researches, are of value to communication engineers, and wherever possible the requisite equipment has been designed from the standpoint of manufacture upon a commercial scale.

NOTES.

INDEX TO VOL. 149 OF "ENGINEERING".

A YEAR ago, in response to various requests, an alteration was made in the method of supplying the indexes to the half-yearly volumes of ENGINEERING, when it was arranged that purchasers of the issues with which the index appeared could, if they wished, buy the copy without the index. The continued urgent need for paper economy now obliges us to suspend this arrangement, at least for the duration of the war. The index to the current volume will be available at the customary time—that is, in the fourth week of July—but it will be published independently of that week's issue of ENGINEERING. No charge will be made for the index or for postage, but it will be sent only to those readers who apply for it. We regret the slight inconvenience and delay which this procedure may cause in certain cases, but believe that the economy in paper, represented by the restriction of the issue to those readers who definitely express a desire for the index, will be accepted as sufficient justification.

INCREASES IN ELECTRICITY CHARGES.

Since the beginning of the war, several electricity supply undertakings have increased their charges, a policy which has led to adverse comment, not only by those most immediately affected, but by members of Parliament and other publicists. The weapons of these critics will be sharpened, and perhaps made more accurate, by a tabular statement which has been prepared by the Electricity Commissioners for the Minister of Transport. This shows the increases in charges made since September, 1939, including those notified by April 30, 1940, and is based on information furnished by 162 undertakings. A supplementary statement deals with the position in London and the Home Counties, and includes certain increases which were brought to the notice of the Commissioners too late for inclusion in the principal statement. Particulars are given of the separate undertakings under headings such as ordinary flat rates and block tariffs, domestic two-part tariffs and business or commercial two-part tariffs. In each case the actual rise in pence, the percentage rise, and the price after the increase are shown, the average increase being about 10 per cent. Details regarding fixed charges and unit charges are given separately. Where the unit charges are in the form of steps, the increases shown in the statement relate to the first step only unless otherwise indicated, and the first and last steps only of the resultant charge are given. Where the fixed charge of a two-part tariff is on a graduated scale, the increase shown relates to the first step of the scale and only the first step is given in the column showing the resultant tariff including the increase. In cases where the area of supply is zoned and higher tariffs apply in the rural than in the urban area, generally speaking the figures relate to the latter only. The statement does not show discounts for prompt payment, though where these have been withdrawn the fact is indicated. Special tariffs for power supplies to large industrial consumers are not dealt with, and where undertakings offer more than one flat rate or stepped rate per unit for power supplies, the rate applicable to the smaller users of power is the one tabulated. Adjustments in the price based on the cost of coal have been omitted.

COMPULSORY COLLECTION OF SALVAGE.

The war has brought about an improvement in our social amenities for which in peace many strove without success. Every factory, shop, home and other establishment collects a certain amount of waste material, other than household refuse, in the course of a year, the disposal of which, especially when the quantities concerned are small, has presented difficulties owing to the reluctance of the local authorities to remove it. Recent appeals for the release of scrap metal from domestic premises have therefore failed, because it seemed to be nobody's business or interest to do the necessary work of collection. This should be altered by the action taken by the Minister of Supply, which requires all local authorities with populations of more than 10,000 to arrange efficient systems for the collection of salvage. All householders in these areas will be required, for their part, to co-operate and to take steps not only to make such materials as scrap metal, waste paper and cardboard available, but to be as economical in their use as possible. Other materials, such as waste food and rags, may be added to the list from time to time. Details of the methods of collection, it is understood, will be given in an Order which is to be issued shortly, and these may vary in districts of different characters. It is pointed out that, while the responsibility for seeing that the collection of salvage is properly organised will rest with the local councils, provision is also to be made for utilising the services of merchants and voluntary organisations. While every engineer in his capacity as householder can play his part in this campaign, which has not been inaugurated too soon, he can also do even more in his industrial capacity to see that there is no waste, either in his factory or in his office. We are glad to learn that a move is already being made to discourage the unnecessary employment of paper for wrapping purposes; paper has much more valuable uses. As far as metal is concerned, too, every household and many factories contain some waste which could with advantage be disposed of, while park railings, ornamental gates, fencing chains, and, possibly, the posts of Belisha beacons, might all with advantage be placed under contribution. We therefore hope that this campaign will be energetically inaugurated without delay and continued at least for the duration of the war.

EXPORT GROUPS IN THE ELECTRICAL INDUSTRY.

As already announced, two main export committees—the Electrical Machinery Export Committee and the Electrical Goods and Apparatus Export Committee—have already been set up in the electrical industry. Owing to the large variety of products that come within the scope of these two bodies, it has become apparent, however, that sectional groups must be established to deal with the domestic problems of export which relate to each class of goods. Sectional export groups dealing, respectively, with turbines (which will cover steam turbines, turbine reduction gears, turbine-driven generators, condensers, turbo-blowers and compressors), electric traction apparatus, alternating- and direct-current motors and generators, transformers and heavy and medium switchgear, have, therefore, been established. Membership of these groups is open to all *bona fide* manufacturers in Great Britain who export or intend to export the products covered and the necessary application should be made to the secretary, Mr. A. G. Seaman, 36, Kingsway, London, W.C.2. Similarly, groups dealing with heating, cooking and domestic electrical appliances, wiring accessories, fans and fractional horse-power motors, water heaters and temperature-control apparatus, insulators, and insulations and conduit fittings, have been established under the ægis of the Electrical Goods and Apparatus Export Committee, the secretary of which is Mr. F. A. Rogers, 36, Kingsway, London, W.C.2. In this case, also, membership of these groups is open to all *bona fide* manufacturers in Great Britain who export or intend to export these products and apply for membership. Other similar groups, under the heading of electrical goods and apparatus, are in process of formation and will be announced later.

AUTOMATIC TRAFFIC LIGHTS AT THE BANK, LONDON.—It is expected that work on the installation of automatic traffic signals at the Bank, London, E.C., will be completed shortly. The scheme is stated to be the largest so far attempted in this country.

THE DISTRIBUTION OF LUBRICATING OIL.—To facilitate the distribution of lubricating oil, the Secretary for Petroleum, Mines Department, requests that, where proper storage exists, all steel and wood lubricating oil barrels and drums should be emptied at once and returned to the oil companies which delivered them. Oil containers must not be used for other purposes, should not be disposed of in other directions, and must not be retained longer than is necessary.

THE THEORY OF MEANDERING.

By H. CHATLEY, D.Sc. (Eng.), M.Inst.C.E.

IT is a well-known fact that a river flowing in an alluvial plain "meanders" in a series of bends which increase the minimum length of the water-course to an appreciable extent and also cause the depths along the course to fluctuate. Owing to bank erosion in the hollows of the bights, the bends slowly travel downstream and, by the development of the curves, the narrow necks between the backs of the loops are occasionally broken through or overflowed. There is thus a condition of instability, leading to the erosion of land area, the undermining of bridge supports and shore works or, alternatively, the silting up and abandonment by the river of cut-off bends ("bayous"). The drainage of surface water is less effective than it might be, and navigation is hampered by the unnecessarily long distances along the water-course and the shallowness of the "crossings" between the bends.

On the other hand, a straight channel in unprotected alluvium is very unstable and, in connection with river control, many engineers have advocated the deliberate introduction of sinuosity into straight reaches.* Again, in river navigation the existence of bends involves depths near the shores in the concaves greater than the average and such "pools" are advantageous for berthing purposes. Still another feature is that the tortuous river often has a somewhat larger storage capacity than the straight channel; although the greater length of channel is offset by reduced widths, there are usually large foreshore areas available at the high stage.

For all these reasons, the characteristic of meandering is of great practical importance to the river engineer. The loss of energy at river bends has been discussed in the writer's articles on river curvature,† and the effects of "cut-offs" are considered in an article on "The Stability of Dredged Cuts."‡ In the discussions on the Hardinge Bridge,§ the writer has remarked on the relation between the "bight-length to cut-off" ratio and the "meander-straight" ratio; and again, in the discussion of Mr. Jack Allen's excellent paper‖ on "The Flow in a Tortuous Stretch of a River," he pointed out that there seems to be a tendency, for the eddy loss in a system of meanders in alluvium to equal the bed-friction loss. Professor A. H. Gibson, in his Vernon-Harcourt Lecture, 1935-6, inclines to the view that such losses exceed the bed friction¶; and Dr. C. M. White has called the writer's attention to the fact that the "form-drag" in an irregular channel may produce areas of "wake" in which there is little or no "skin-drag," so that the latter may be less than half the total resistance.

As a basis for the study of meanders, it is useful preliminarily to consider a stretch of river in a very broad alluvial plain, as long as possible consistent with relatively small variation of sectional area and discharge, and to notice the relation between the actual length and the air-line distance between the ends. This may be called the "meander-straight" ratio. Its value is often between $1\frac{1}{2}$ and 2, but in some exceptional cases it may rise to 3 or even higher; for general purposes, in an average sinuous river, it may be taken as 2. If now the effect of curvature adds form-drag at least equal to the bed friction and the length of the *thalweg* (deep course) is twice the air-line distance, the result is that the purely frictional resistance per unit length in a sinuous reach of river (in alluvium) is of the order of one-fourth of that which would occur in a straight stream with the same sectional area and same total fall. Using the Manning or a similar formula, some rather interesting results may be derived from this approximation. If the sinuous length is l_s, the air-line length l, the drop h, the hydraulic radii m_s and m, respectively, and the discharge Q, the mean velocity in the sinuous river is

$$v_s = \frac{1}{n} \cdot m_s^{\frac{2}{3}} \left(\frac{h}{2\,l_s}\right)^{\frac{1}{2}} \quad . \quad . \quad (1)$$

If the river is rectified,

$$v = \frac{1}{n} \cdot m^{\frac{2}{3}} \left(\frac{h}{l}\right)^{\frac{1}{2}} \quad . \quad . \quad (1a)$$

By the Kennedy-Lacey rule (assuming constant silt grade)*, we have for stability of bed

$$v_s = \mathrm{K}\, m_s^{\frac{1}{2}} \quad . \quad . \quad (2)$$

$$v = \mathrm{K}\, m^{\frac{1}{2}} \quad . \quad . \quad (2a)$$

so that

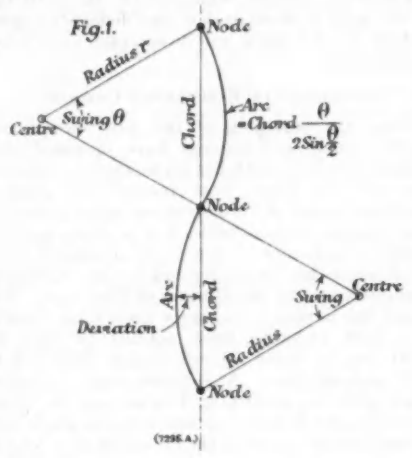
$$\frac{v}{v_s} = \left(\frac{m}{m_s}\right)^{\frac{1}{2}} \quad . \quad . \quad (2b)$$

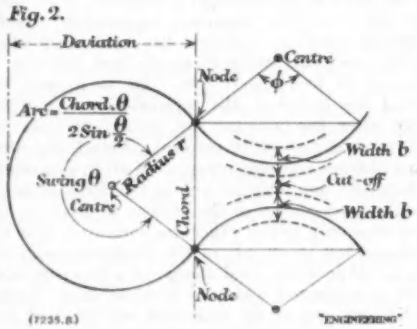
and by the continuity relation

$$\mathrm{Q} = v_s\, m_s\, p_s = v\, m\, p \quad . \quad . \quad (3)$$

where p_s, p are the respective perimeters.

From (3) and (2*b*) we have





$$\frac{p}{p_s} = \frac{v_s\, m_s}{v\, m} = \left(\frac{m_s}{m}\right)^{\frac{1}{2}} \cdot \left(\frac{m_s}{m}\right) = \left(\frac{m_s}{m}\right)^{\frac{3}{2}} \quad . \quad (4)$$

and from (1) (1*a*) and (2*b*) we have

$$\frac{m}{m_s} = \left(\frac{l}{2\,l_s}\right)^2 \quad . \quad . \quad . \quad (5)$$

indicating a reduction of m, a great increase of the perimeter, and a decrease of velocity with straightening.

While no great importance should be attached to the numerical indications of such a calculation (the coefficient 2, bed resistance to friction, is, of course, uncertain), it is of interest to consider the arithmetical results in an actual case. Consider a reach of, say, 100 km., with a fall of 1 in 10,000, a sinuosity of 2, a mean hydraulic radius of 4 m., a discharge of 10,000 cub. m. per second, and a value of n equal to, say, 0·02, $\left(\frac{1}{n} = 50\right)$. The mean velocity in the sinuous channel,

$$v_s = 50 \times (4)^{\frac{2}{3}} \times \left(\tfrac{1}{20000}\right)^{\frac{1}{2}} = 0{\cdot}89 \text{ m. per second.}$$

By equation (5), the hydraulic radius in the rectified channel may be

$$m = 4 \times \left(\tfrac{1}{2}\right)^2 = \tfrac{1}{16} \text{ m.};$$

and by (2*b*), the velocity in the rectified channel would be,

$$v = 0{\cdot}89 \times \left(\frac{\frac{1}{16}}{4}\right)^{\frac{1}{2}} = 0{\cdot}11 \text{ m. per second.}$$

The initial perimeter is $10{,}000 \div (4 \times 0{\cdot}89) = 2{,}808$ m. By (4), the new perimeter would be $\left(\frac{m_s}{m}\right)^{\frac{1}{2}}$ times the old value

$$= \left(\frac{4}{\frac{1}{16}}\right)^{\frac{3}{2}}; \text{ } i.e., \text{ } 512$$

times as wide, or nearly 1,500 km. This apparently absurd result implies that the increased slope can only be stable if the stream spreads in a sheet all over the valley. If confined to a channel it would tend to erode without limit until the water falls. Is this true? An interesting variation can be derived from G. Lacey's universal formula for regime

$$v = 4\,(2\,g)^{\frac{1}{2}}\, m^{\frac{2}{3}}\, s^{\frac{1}{6}} \quad . \quad . \quad . \quad (6)$$

which is reputedly independent of silt grade.* (It is not quite clear if the slope should or should not include tortuosity resistance or is simply the frictional value.)

This is associated by Lacey with his discharge formula

$$v = \frac{1}{n}\, m^{\frac{2}{3}}\, s^{\frac{1}{2}} \quad . \quad . \quad . \quad (7)$$

Using this form for the two cases as above, and also the regime formula, it is found that

$$\frac{m}{m_s} = \left(\frac{l}{2\,l_s}\right)^2 \quad . \quad . \quad . \quad (5a)$$

which is of the same type as formula (5), but not quite so extreme. In the writer's article on "Stable Sectional Form of Alluvial Rivers,"† attention has already been called to the manner in which width appears to increase with slope.

It seems clear that the ratio of total fall to pure bed-friction fall in a tortuous river is certainly not less than 2; and if it exceeds two, the formulæ (5) or (5*a*) show a still more marked diminution of m with straightening. We thus come to the rather unexpected conclusion that a stream rectification without bank protection will inevitably lead to a shallowing and widening of the stream. What will happen if there is bank protection? Lacey's rules are based on observations of unconfined streams, so that they will not apply in this case; which introduces the condition, for a wide channel, that the wetted perimeter is practically constant.

The discharge formulæ will still apply, say

Manning.	*Lacey.*
$v = \frac{1}{n}\, m^{\frac{2}{3}}\, s^{\frac{1}{2}}$	$v = \frac{1}{n}\, m^{\frac{2}{3}}\, s^{\frac{1}{6}}$
$\mathrm{Q} = v\, m\, p$	
$\frac{\mathrm{Q}}{m\,p} = \frac{1}{n}\, m^{\frac{2}{3}}\, s^{\frac{1}{2}}$	$\frac{\mathrm{Q}}{m\,p} = \frac{1}{n}\, m^{\frac{2}{3}}\, s^{\frac{1}{6}}$
$m = \left(\frac{n\,\mathrm{Q}}{p\sqrt{s}}\right)^{\frac{3}{5}}$ or $m \propto \left(\frac{1}{s}\right)^{\frac{3}{10}}$	$m = \left(\frac{n\,\mathrm{Q}}{p\sqrt{s}}\right)^{\frac{3}{4}}$ or $m \propto \left(\frac{1}{s}\right)^{\frac{3}{8}}$

or, say,

$$m \propto \left(\frac{1}{s}\right)^{0{\cdot}3}$$

$$\frac{m}{m_s} = \left(\frac{l}{2\,l_s}\right)^{0{\cdot}3} \quad . \quad . \quad . \quad (8)$$

As the perimeter is fixed,

$$v \propto \frac{1}{m}$$

or

$$\frac{v}{v_s} = \left(\frac{2\,l_s}{l}\right)^{0{\cdot}3}.$$

Thus, if

$$\frac{l_s}{l} = 2,$$

$$\frac{m}{m_s} = \left(\tfrac{1}{2}\right)^{0{\cdot}3} = 0{\cdot}66$$

and

$$\frac{v}{v_s} = 1{\cdot}5.$$

Note that the velocity is increased, while it was decreased when the banks were free.

While the Kennedy-Lacey rule is based on laterally unconfined streams, yet the expression

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* "La Forme du Lit des Rivières à Fond Mobile." By M. Fargue. Paris; *Annales des Ponts et Chaussées* (1868 *to* 1884).

† See ENGINEERING, vol. 131, pages 196 and 260 (1931).

‡ *Ibid.*, vol. 146, page 754 (1938).

§ *Journ. Inst.C.E.*, December 1938, page 207.

‖ *Ibid.*, October, 1939, page 387.

¶ *Ibid.*, October 1936 (Supplement), page 709.

* "The Flow of Water in Alluvial Channels," by G. Lacey. *Proc. Nat. Inst. Sciences*, India, vol. iv, No. 4, page 413 (1938).

* *Loc. cit.*; and "Uniform Flow in Alluvial Rivers and Canals," *Proc. Inst.C.E.*, vol. 237, page 421 (1934).

† See ENGINEERING, vol. 146, page 741 (1938).

$v_1 \propto \sqrt{m}$ for a stable bed is a partial indication that, unless $\frac{v}{\sqrt{m}}$ is constant, the bed is not stable. In this case $v\,m$ is constant, showing that the bed is not stable and some erosion must occur.

The late John R. Freeman was a keen advocate of a rectification of the Hwai and Yellow Rivers by constructing reinforced-concrete pile groynes, which would fix the perimeter. It seems clear that this would involve an increase of velocity, but the conditions of stability are not definite. Scouring tends to increase the hydraulic radius which, in its turn, might reduce velocity; but stability cannot be reached until the scoured material has created an additional resistance or, by deposition at the mouth, has flattened the slope until the conditions will permit the flow formula to be satisfied without further scour.

Let us now turn to the reverse aspect of the problem, the development of sinuosity from an initially straight channel. Any slight inequality of flow, asymmetry of channel or the entrance of a tributary will initiate the process of meandering. On the face of it, all the above formulæ will still be applicable as reciprocals, and, in particular, we shall have

$$\frac{m_s}{m} = \left(\frac{2\,l_s}{l}\right)^{3 \text{ or } 2} \quad . \quad . \quad . \quad . \quad (5c)$$

$$\frac{p_s}{p} = \left(\frac{m}{m_s}\right)^{\frac{2}{3}} = \left(\frac{l}{2\,l_s}\right)^{4\frac{1}{2} \text{ or } 3} \quad . \quad . \quad (4a)$$

$$\frac{v_s}{v} = \left(\frac{m_s}{m}\right)^{\frac{1}{3}} = \left(\frac{2\,l_s}{l}\right)^{\frac{1}{2} \text{ or } 1} \quad . \quad . \quad (2c)$$

i.e., the hydraulic radii will be increased by sinuosity, perimeters will be reduced and mean velocities will be increased. As a result of the increased velocity, in spite of bed stability, the sides of the concaves will be scoured. The length of the loops will increase to a maximum or until intersections occur, and the eroded material, by depositing on concaves, will gradually shift the loop downstream. Tiffany and Nelson* have shown that the rate of development of meanders depends largely on silt supply.

If the general trend of the river be taken as a more or less straight give-and-take line, the meanders intersect it at what may be termed the nodes. Assuming circular arcs and constant radius, we have a geometrical relation as shown in Figs. 1 and 2, on the opposite page.

The cut-off

$$= \text{chord} - \left[2\,r.\ \text{vers}\,\frac{\phi}{2} + b\right]$$

$$= \text{chord} - \left[2\,r.\ \text{vers}\left(\frac{\theta}{2} - 90\right) + b\right]$$

Bight/cut-off ratio

$$= \frac{r\,\theta + r\,\phi}{\text{cut-off}}$$

$$= \frac{2\,r\,\theta - \pi\,r}{\text{cut-off}}.$$

The arc/chord ratios are as follows:—

Swing, θ deg.	Arc/chord.
0	1·0
30	1·012
60	1·047
90	1·111
120	1·209
150	1·355
180	1·571
225	2·125
270	3·332
300	5·24
330	11·11
350	34·99

As soon as the angle of swing exceeds 180 deg., the cut-off distance becomes definitely less than the chord. If b be the width of the channel, the cut-off distance is zero when

$$(\text{chord} - \text{width}) = 2\,r.\ \text{vers}\left(\frac{\theta}{2} - 90 \text{ deg.}\right);$$

so that the maximum possible angle of swing is defined by the expression:—

$$\theta = 180 \text{ deg.} + 2\left[\text{vers}^{-1}\left(\frac{\text{chord} - \text{width}}{2 \times \text{radius}}\right)\right].$$

Thus, if the width be one-quarter the chord, and the radius three-quarters the chord,

$$\theta = 180 \text{ deg.} + 2\,[\text{vers}^{-1}\,(\tfrac{1}{2})].$$

As

$$\text{vers}\ \theta = (1 - \cos\,\phi),$$

this

$$= 180 \text{ deg.} + 2\cos^{-1}(\tfrac{1}{2}) = 300 \text{ deg.}$$

for which the arc/chord ratio is 5·24. Obviously, the larger the width/chord ratio, the smaller the maximum swing angle; and, similarly, the larger the radius/chord ratio, the smaller the maximum swing. These figures are merely indicative, since the arcs are not circular and the chord lengths are not quite constant, even in uniform material and a uniformly sloped valley. A study of an actual river will indicate fairly well the mean radii, chords and maximum swings, and a comparison of *thalweg* length and air-line distances will give the arc/chord length.

It is not yet clear what determines the ratio chord/width, but experiments in artificial straight channels seem to show that there is a fairly definite relation. A careful tabulation of the mean chord ("internodal length") in relation to the mean width for actual rivers should reveal an empirical relation. It must be observed, however, that, as the sinuosity develops, the widths decrease; and also, where curvature is greatest, widths are least, so that the conditions are rather involved. The ultimate parameters are simply the discharge, the soil material and the general land slope (approximately equal to the hydraulic gradient of the rectified river). In some rivers the sinuosity may reach a kind of form-stability before cut-offs occur. This may be associated, perhaps, with the fact that in pipes the minimum curvature loss of energy occurs when the radius is about five times the pipe diameter; so that, in a circular curve, the minimum resistance occurs when the vertex curvature has attained a certain value. Any sharper curvature will develop a higher resistance to flow. There is certainly a tendency to stop meandering when a definite slope has been attained.

It is suggested that river engineers should carefully tabulate the following particulars for the alluvial stretches of any river they may have to do with: (1) the *thalweg*, or sinuous length, along the deepest course; (2) the air-line or direct length along the shortest course which the river might take—if there are immovable obstacles, this line will be a series of tangents past these obstacles and not simply a straight line; (3) the number of reversals of curvature in the *thalweg*; (4) the bank widths at numerous characteristic points; (5) the minimum radii of curvature in bends; (6) the angle of swing when cut-offs are imminent; (7) the hydraulic gradient in the middle of long straight reaches, as compared with the general gradient along the *thalweg*; (8) the maximum depths at various characteristic points, especially in bends; (9) changes of bed material. Tabulation of these, in sufficient detail for any one river, and comparison with similar particulars for other rivers, must eventually lead to certain rules of correlation.

* "Studies of the Meandering of a Model Stream," by J. B. Tiffany and G. A. Nelson. *Trans. Am. Geophysical Union.* Reprint by United States Waterways Station, Vicksburg, Mississippi (1939).

LETTER TO THE EDITOR.

THE LATE PROFESSOR SIR THOMAS HUDSON BEARE.

TO THE EDITOR OF ENGINEERING.

SIR,—May I add to the long list of activities of the late Sir Thomas Hudson Beare set out in your issue of June 21, page 607, one for which the Institution of Mechanical Engineers will always be specially grateful, namely, his chairmanship, from its formation in 1924, of the Joint Committee with the Scottish Education Department on National Certificates and Diplomas. This Committee has, during the 16 years of its existence, awarded about 2,000 Certificates and Diplomas in Scotland. Sir Thomas's life-long experience and wonderfully alert mind made him an ideal chairman, quick to seize on the essential point and to make a just decision.

Yours faithfully,
J. E. MONTGOMREY,
Secretary.

The Institution of Mechanical Engineers,
Storey's Gate, London, S.W.1.

THE LATE SIR JOCELYN THORPE.

MANY old students, both of the Imperial College and of Owens College, Manchester, will hear with regret of the death of Sir Jocelyn Thorpe, which took place on June 10, at his house at Cooden Beach, Sussex. Sir Jocelyn was not only an able lecturer, but was a genial and very human personality who endeared himself to all with whom he came in contact. He was Professor of Organic Chemistry at the Imperial College from 1914 to 1938, previously holding a Sorby Research Fellowship of the Royal Society, from 1909 to 1913. His connection with Owens College extended from 1895 to 1910. Being appointed to a Research Fellowship in the former year, he passed through the stages of assistant lecturer, lecturer and senior lecturer. He was born in 1872 and was educated at Worthing College; King's College, London; the Royal College of Science; and the University of Heidelberg.

Sir Jocelyn's activities outside his university work were extensive and important. Their range may be indicated by saying that he served on the Advisory Council of the Department of Scientific and Industrial Research from 1916 to 1922; was a member of the Safety in Mines Research Board from 1924 to 1935; and was chairman of the Explosives in Mines Committee of the Department of Mines; and a member of the Dyestuffs Development Committee of the Board of Trade from 1925 to 1934. Some of his most important work was on the Chemical Defence Committee of the War Office. When gas warfare was introduced by the Germans in the early part of 1915, Thorpe was one of the first two chemists who were called in, in connection with the development of defensive and retaliatory measures. He continued his association with the chemical warfare branch for many years. He was President of the Chemical Society from 1928 to 1931; Member of Council of the Royal Society from 1923 to 1925; President of the Institute of Chemistry from 1933 to 1936; Longstaff Medallist of the Chemical Society in 1921; and Davy Medallist of the Royal Society in 1922. His many other activities did not prevent him from contributing many papers to the *Journal of the Chemical Society* and publishing various chemical treatises, of which the best known is probably the monumental *Thorpe's Dictionary of Applied Chemistry*, of which he was initiator and co-editor.

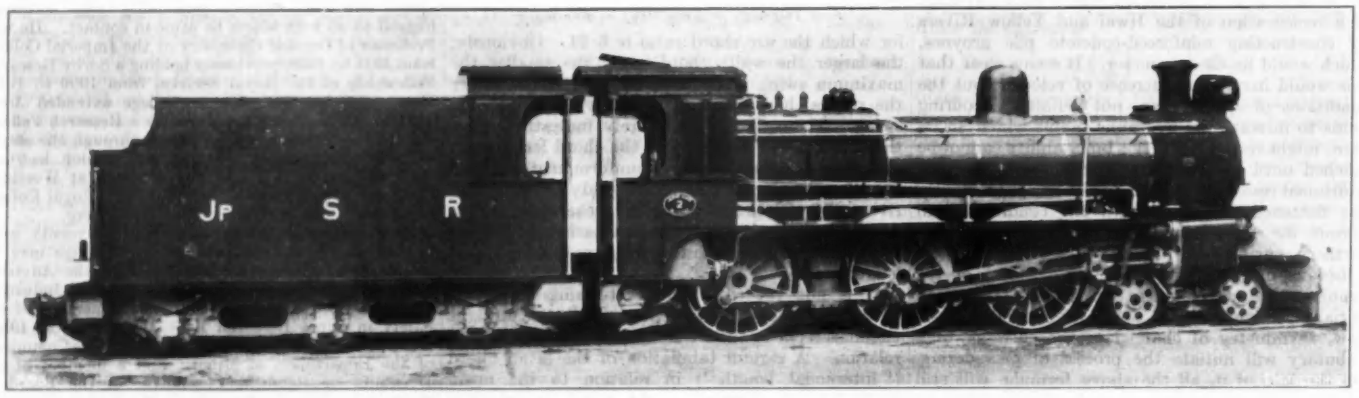
THE LATE PROFESSOR A. FOWLER, C.B.E., F.R.S.

IT is with regret that we have to record the death of Professor A. Fowler, C.B., F.R.S., which occurred at his home in Kent-avenue, Ealing, London, W.13, on June 24. Albert Fowler, who was Emeritus Professor of Astro-Physics, Imperial College, South Kensington, and a former Yarrow Research Professor of the Royal Society, was born in 1868. He gained a scholarship at the Royal College of Science, Imperial College, South Kensington, then known as the Normal School of Science, in 1882, at the early age of 14, and, in 1885, was awarded the degree of Associate of the Royal College of Science in mechanics. In 1887, he was appointed demonstrator in astronomy and later took on the duties of computer to the Solar Physics Committee. His work in connection with solar and stellar spectra soon brought him to the fore and he was chosen as a member of British Government Eclipse Expeditions in 1893, 1896, 1898, 1900, 1905 and 1914. For many years he carried on work connected with the analysis of spectra and contributed numerous papers on the subject to the Royal Society, the Royal Astronomical Society, and other scientific bodies. From 1923 until his retirement in 1934, he held the position of Yarrow Research Professor of the Royal Society, and, in 1926, was President of Section A (Mathematical and Physical Sciences) of the British Association Meeting at Oxford. In November, 1936, he delivered the 23rd Thomas Hawksley Lecture before the Institution of Mechanical Engineers, his subject being "The Spectroscope and the Atom."

Professor Fowler was the recipient of many honours. He was a past-president of the Royal Astronomical Society and of the Institute of Physics, and was made an F.R.S. in 1910 and a C.B.E. in 1935. He held the honorary D.Sc. degree of the Universities of Bristol, Durham and Leeds, and the honorary Sc.D. degree of Cambridge University. He was corresponding or foreign member of several overseas scientific academies and received the Valz Prize of the Académie des Sciences, Paris, in 1913; the Gold Medal of the Royal Astronomical Society in 1915; the Royal Medal of the Royal Society in 1918; the Henry Draper Gold Medal of the National Academy of Sciences, Washington U.S.A., in 1920; and the Catherine Wolfe Bruce Gold Medal of the Astronomical Society of the Pacific in 1934. Professor Fowler served for some years as a member of the Advisory Council to the Department of Scientific and Industrial Research and as secretary of the International Astronomical Union.

4-6-0 TYPE PASSENGER LOCOMOTIVE FOR JAIPUR STATE RAILWAY.

MESSRS. THE HUNSLET ENGINE COMPANY, LIMITED, LEEDS.



4-6-0 TYPE PASSENGER LOCOMOTIVE FOR JAIPUR STATE RAILWAY.

THE generally progressive outlook of the native states of India is well illustrated by the addition to the rolling stock of the Jaipur State Railway of a 4-6-0-type passenger locomotive using superheated steam. The line has now 180 miles of permanent way open, with a further 84 miles under construction, and is of 1-m. gauge. The addition of the engine now described, a photograph of which is reproduced on this page, brings the locomotive stock up to 13 in number. The new locomotive has been built by Messrs. The Hunslet Engine Company, Limited, Jack-lane, Leeds, 10, to the inspection of the consulting engineers to the Jaipur State Railway, Messrs. Robert White and Partners, 3, Victoria-street, London, S.W.1. The total weight is 63·5 tons in working order, divided into 35 tons 12 cwt. for the engine and 27 tons 18 cwt. for the tender. Of the engine weight, 27 tons are available for adhesion, this weight being equally distributed over the three coupled axles, the maximum axle load, therefore, being 9 tons. The tractive effort, at 75 per cent. of the boiler pressure, which is 160 lb. per square inch, is 12,610 lb. and the adhesion ratio is 4·821. The weight of the engine empty is 32 tons 17 cwt. and that of the tender in the same condition is 11 tons 4 cwt. The tender has a capacity of 5·5 tons of coal and 2,500 gallons of water. The wheelbase permits a curve of 300 ft. radius to be traversed without difficulty.

The cylinders are 16½ in. bore by 22 in. stroke, and have piston valves actuated by Walschaert valve gear. Detroit sight-feed lubricators are fitted. The coupled driving wheels are 4 ft. 9 in. in diameter and those of the leading bogie are 2 ft. 4½ in. in diameter, the tender wheels being also of this latter diameter. The frames are of the plate type and A.B.C. automatic couplers are fitted. The boiler, which is of the Belpaire type, has a total heating surface of 896 sq. ft., of which 108 sq. ft. is provided by the firebox, 207 sq. ft. by the large tubes, 431 sq. ft. by the small tubes, and 150 sq. ft. by the superheater elements, of which there are 13, the superheater being of the "Melesco" type, supplied by Messrs. The Superheater Company, Limited, Bush House, Aldwych, London, W.C.2. The boiler tubes are of steel and the firebox of copper with copper stays. The grate area is 16 sq. ft. The steam fittings are arranged on a steam stand on the top of the firebox and controlled, where necessary, from the footplate. The stand can be isolated, if required, while the boiler is under steam, by means of a master valve. There are two Ross pop safety valves, top feed clackboxes fed by two Gresham and Craven No. 8 injectors, and a blow-off cock of the "Everlasting" type. Vacuum brakes are fitted to both engine and tender, actuated by a Gresham and Craven ejector. The tender has also a powerful screw hand brake. The lighting equipment, which includes a headlight, is electric.

AUSTRALASIAN INSTITUTE OF MINING AND METALLURGY.—The Gold Medal of the Australian Institute of Mining and Metallurgy has been awarded to Sir Herbert Gepp, in recognition of his services to mining and metallurgy, particularly in connection with the development of flotation processes for the treatment of complex sulphide ores and with the establishment of the electrolytic zinc industry in Australia. The presentation is to be made at a meeting of the Institute which will be held at Broken Hill in August.

PROTECTIVE FILMS ON TIN-PLATE.

WHEN commenting on the annual report of the International Tin Research and Development Council, on page 302, *ante*, we referred briefly to a process for producing a protective film on tin-plate intended for the manufacture of tins to contain food products. Some additional data regarding the process have now been made available in a publication recently issued by the Council, in which it is stated that the protective film is an oxide and that it is so thin that it is invisible. The film is intended to protect the underlying tin from the action of sulphur compounds, produced by a slight decomposition of the proteins contained in certain types of vegetables, meat and fish products as a result of the sterilisation process. This decomposition of the proteins may cause blue or black stains to appear on an unprotected tin-plate surface, and this discoloration is not only unsightly but may, in extreme cases, affect the appearance of the contents. Moreover, in the case of some vegetables, the colour may be adversely affected, being changed from green to an unpleasing yellow. Manufacturers usually prevent these effects by coating the interior of the container with a special sulphur-resisting lacquer, but this operation, though effective, is somewhat expensive, and, in a few cases, the lacquer may react unfavourably on the flavour of the food product.

The method first employed in the Council's laboratories for producing the oxide film on the tin was to immerse the tin-plate in a hot solution of chromic acid for fifteen minutes. This process, however, had several disadvantages, the chief being that the film of palm oil, left on the tin-plate from the hot-tinning operation had first to be completely removed—an operation which was found to be somewhat difficult. Experiments were therefore carried out with alkaline reagents in an endeavour to obtain a solution which would simultaneously remove the film of oil and produce an oxide film. Eventually, a hot alkaline solution, containing sodium phosphate and a chromate, was found to serve this purpose. This process, like the previous one involving the use of chromic acid, is the subject of a provisional British patent. An interesting point is that further work on the newer process has resulted in the reduction of the time required from 15 minutes to 2 minutes, with the possibility of a still further reduction. The film, as now developed, has been found to give good protection from sulphur staining and to be effective in the case of tinned vegetables, meat products and soups, while preliminary tests with fish products are promising. Tests with various kinds of fruit, however, have given poor results, as the film appears to be slowly dissolved by the citric acid present.

LABOUR NOTES.

THE following editorial note appears in the June issue of *Man and Metal*, the journal of the Iron and Steel Trades Confederation:—"It is with regret that we have to record the passing of two outstanding figures in the sheet and tin-plate trades in the persons of Mr. D. C. Lysaght and Mr. H. C. Thomas. Both of them were known for the active and important parts they played in the joint negotiating machinery in both trades. For many years, Mr. Lysaght acted as Secretary of the Sheet Trade Committee, and he and his cousin, Mr. W. R. Lysaght, were instrumental in forming the Sheet Trade and Galvanising boards. He was always recognised by the workers as a good employer, and the amount of energy he put into his work undoubtedly at times affected his health, which, no doubt, prevented him from reaching the allotted span of 'three score years and ten.'"

"Mr. H. C. Thomas," the writer goes on to say, "had been for years the Secretary of the Welsh Tin-Plate and Sheet Manufacturers' Association, but he was better known to the workmen's representatives as the secretary of the employers' side of the Joint Industrial Council. He was undoubtedly one of the main conciliatory influences in the tin-plate trade, and many an awkward situation might have developed, but for the genial and tactful way H. C., as he was called, used his influence. The employers have lost an excellent servant and the men have lost a good friend, because those who came in close contact with him always felt that, while he was concerned about looking after the interests of the employers, he never allowed the sense of justice and fair play to be obscured. Both these men have made their contributions to the tin-plate and sheet trades, and the community which depends upon these industries for its livelihood is better for their having lived."

The basic rates of pay for skilled labourers engaged in the use of oxy-acetylene hand metal cutters in H.M. Dockyards and other Admiralty establishments are revised by an award recently issued by the Industrial Court. The rates now are:—Men with less than six months' service, 36*s.* a week; men with six months' and less than 12 months' service, 40*s.*; men with 12 months' service and over, 44*s.* The industrial bonus, which at present is 27*s.* a week, is payable in addition. The trade union side of the shipbuilding trade joint council for Government Departments claimed a basic rate of 48*s.* a week for men employed in burning off the heads or points of rivets or bolts or the cutting of plates, sections or castings for use in ship work.

In the House of Commons last week, the Chancellor of the Exchequer appealed to patriotic citizens, who were in a position to do so, to lend money to the nation without interest till the war is over. Mr. C. Dukes, the general secretary of the National Union of General and Municipal Workers, has been authorised by the general council of the union to place at the disposal of the Government the sum of 250,000*l.* free of interest.

In the course of a letter to the editor of *The Times*, dated June 15, Mr. Ed. Armelin, managing director of Messrs. Chambon, Limited, Hammersmith, said:—"When I arrived at the works this morning I was advised that our men had spontaneously decided, without one exception, to hand over their Saturday overtime money to the Red Cross, for the duration. This needs no further comment, except that I have advised the Minister of Labour and National Service of the magnificent 'Bevin spirit' that he has so rapidly spread throughout his 'troops,' who are now fighting the armaments battle."

With a view to securing rapid discharge of ships in port and speedy clearance of goods, the Minister of Labour and National Service has divided the country into four regions, where regional port labour inspectors will exercise control over the movement of dock labour. The headquarters of the regions will be at London, Liverpool, Newcastle and Edinburgh, and all dock labour within each of these regions will be regarded

as available for work as may be required in any port in the region.

Employers in the cotton spinning and weaving industries will pay 350,000 workpeople an additional 25,000*l.* in wages in the first week of July as a result of an advance in the official cost of living figure issued by the Ministry of Labour and National Service. This now stands at 81 points above the 1914 level on June 1, as compared with 80 points a month ago.

Employees of arms factories under the Ministry of Supply who have, for a long time, been working at high pressure on vitally important production are, it is announced, still further increasing their output. Workers at a Royal Ordnance factory in Scotland have asked that day and night shifts should run for periods of four weeks instead of two as at present so that "lost hours" caused by changes of shifts may be reduced by one-half. Their request was made through the local representative of the Amalgamated Engineering Union. In this factory alone the immediate effect of adopting the suggestion is that an average of three hours a week will now be lost instead of six hours per week. It is stated that it may be possible further to reduce this figure.

Mr. Ernest Bevin, the Minister of Labour and National Service, accompanied by Mr. R. Assheton, Parliamentary Secretary to the Ministry, and Sir Thomas Phillips, permament secretary, met representatives of about 120 voluntary organisations concerned with industrial welfare at the Ministry of Labour, last week. Two former Ministers of Labour—Lord Rushcliffe, chairman of the Voluntary Services Advisory Committee, and Miss Margaret Bondfield, chairman of the women's group of a number of voluntary associations—were among those present. Mr. Bevin appealed for the co-operation and assistance of the organisations both centrally and locally. He explained the local machinery which was being set up and the proposals he had in mind for bringing in the voluntary associations locally for the purpose of central co-operation. Mr. Bevin suggested the formation of a Central Consultative Council, and announced that Lady Cynthia Colville had agreed to act as chairman of such a council. A general discussion took place and questions were raised. The organisations expressed their desire to co-operate whole-heartedly with the Minister, and agreed to establish a consultative council as he had suggested.

According to a recent issue of *Industrial and Labour Information*, the German Minister of Labour has sent a circular to the regional employment offices concerning the training of additional metal workers. The regional employment offices are to see that suitable factories provide facilities for the training of a reasonable number of semi-skilled workers even if they themselves do not need additional workers at the moment. The number of trainees must be determined in accordance with the total demand of all factories. The training may take place either individually in the factory or in special training workshops and should last at least three months. It does not affect in any way the short-period training of workers to use machinery and to carry out other simple operations in accordance with each factory's own needs.

The detailed regulations laid down are as follows :—(1) every regional employment office must organise training facilities in such a way as to bring about an increase of a specified percentage in the number of metal workers available in the district, and if workers are not available in the district for training purposes they must be brought from other districts ; (2) firms should, as far as possible, train workers from their own labour force, and the employment offices must provide unskilled workers including women in suitable cases to take the places of those who are undergoing training ; (3) the training is to be more especially undertaken by factories which need semi-skilled workers and by factories which have an unsound relationship between the number of skilled and semi-skilled workers and which, as a result of training, can place skilled workers on important war work ; any arrangements that may exist for co-operation among a group of factories must be made use of in the training programme ; (4) in deciding as to the distribution of trainees by factory and by occupation, close contact must be maintained with the district technical office ; the district branches of the Labour Front office for vocational training and factory leadership ; the industrial departments of the economic chambers and the armaments inspectors ; (5) the cost of the training is borne by the firm ; only in connection with the measures mentioned under (3) above may a contribution be made by the National Employment Fund, on condition, however, that the firms also contribute.

FUEL INJECTION IN OIL ENGINES IN RELATION TO COMBUSTION.*

By G. W. A. Green, B.Sc.

(*Concluded from page* 593.)

Note.—We regret that, owing to the abridgment of this paper, certain terms have appeared on pages 592 and 593, *ante*, without definition, and therefore their meaning may not be clear. We give herewith an explanation of these terms. (1) "Release pressure," referred to in the first line of the first column of page 593, *ante*, is the opening or breaking pressure of the atomiser determined by the spring tension and observed by means of a pressure gauge attached to a hand test pump. (2) In the first column of page 593, the twenty-seventh line from the bottom, reference is made to the "trapped fuel." The trapped fuel is the fuel trapped after the end of injection between the fuel-pump delivery valve and the nozzle needle valve. In order to make clear the meaning of the remainder of that paragraph, the following should be inserted before the beginning of the sentence in question :—"A partial theory of this chattering action has been worked out. It is based on certain simplifying assumptions and is given in Appendix I of the paper. The conclusions have been checked experimentally and are correct qualitatively, but not quantitatively. They show that instability is promoted by (1) a big volume of fuel under compression near the nozzle ; (2) a big value of the ratio needle-seat diameter/needle-guide diameter ; (3) an atomiser spring of low stiffness ; (4) a high release pressure." (3) The last paragraph in the first column of page 593 begins with the words "values of pintle over body diameter," whereas this should read "values of the ratio needle-seat diameter/guide diameter." (4) In the third column on page 593, twenty-seventh line from the bottom, reference is made to the "actual velocity." This should read "the actual velocity of the flow of fuel in the delivery pipe."

The author has made many attempts to prevent the occurrence of secondary injections caused by surges in the delivery pipe, but so far he has found no sovereign remedy. They only occur under certain circumstances. A particular engine may be subject to them at particular parts of the load or speed range. The obvious line of attack is to raise the release pressure, or reduce the trapped pressure,† or both. Raising the release pressure raises the injection pressure, resulting in an increase in the violence of the spill, and thus increasing the intensity of the resulting surge. The net gain is very small. The same applies to the lowering of the trapped pressure. An attempt was next made to cancel out the waves by means of partial reflection. An obstruction in the form of a plug having a hole through it equal to half the cross-sectional area of the pipe, was placed in the delivery pipe. This was placed at one-third of the distance along the pipe from the pump to the nozzle. It was argued that a disturbance travelling along the pipe from the pump would be partially transmitted and partially reflected at the obstruction ; that the reflected portion would be again reflected at the delivery valve and that its crest would reach the nozzle at the same moment as the trough of the transmitted portion. They would thus cancel one another out. The intensity of the surge was certainly reduced, but the improvement hoped for in the fuel consumption of the engine did not materialise. Similar experiments were made by placing "capacities" at various points, consisting of volumes of fuel to absorb the surge. In this case, too, any gain due to reduction of the intensity of the surge was more than offset by accompanying disadvantages ; and the fuel consumption went up. A further set of experiments was made in which it was attempted to produce viscous damping of the surge. A pipe of larger bore than normal was used and the cross-section was reduced to normal by inserting a wire through the full length of the pipe. In this way the wetted perimeter of the channel was greatly increased and the mean hydraulic depth reduced without altering the cross-sectional area. The resistance to normal flow was little affected, whilst the resistance to the extremely high-speed flow associated with the surge was much increased. The surge was certainly damped out very effectively ; but there was no opportunity to see whether there was any corresponding gain in fuel consumption, because it was found that after quite a short run the wire in the pipe broke into a number of short pieces. The breaks occurred at each bend in the pipe and were evidently due to a fatigue effect of some kind. Wires of copper brass, mild steel, and spring steel were tried in turn without avail. Possibly some form of indented tube might be equally effective and last longer, but it would involve an increase of volume. Another way of laying the pipe "bogey" is to suppress the pipe altogether and combine pump and atomiser in one unit. Many designs have been proposed to this end and many sets have been tried. At least one engine in large-scale production is using this system. On paper it renders a differential needle valve unnecessary and in practice seems to render it more or less impossible.

Basis for Selection of Equipment.—A matter which has always attracted the author is the selection of injection equipment to suit a given design of engine. Makers of equipment issue data as to the capacity of their pumps, but if these alone were taken into account by an engine designer, he would land himself into considerable difficulties. The author contends that enough experience is available to bring a certain amount of logic to bear on the question. Remembering the great number of variables entering into the problem, no rigid solution can be expected, but the author has collected and analysed such information as he has been able to obtain from actual practice regarding the relationship of the characteristics of injection equipment to engine design. The necessary particulars have been obtained of some eighty-five engines of small and medium size, covering a range of cylinder diameter from 70 mm. to 420 mm., and a speed range from 300 r.p.m. to 3,000 r.p.m. The list might, of course, be extended with advantage, and the author would welcome additional information concerning up-to-date details of engines, which he would analyse, and would then revise his conclusions in any particular that might be indicated by the results. The figures so far available show a most surprising variation between the practice of different makers, and sometimes even between different engines of the same series. Many different characteristics have been plotted and the three diagrams reproduced later in the paper (Figs. 4-6) show the most significant relationships that could be found. In order to bring out the tendencies as clearly as possible, logarithmic plotting has been used. It has not been possible to find any relationships giving points lying on a well-defined curve ; and this is to be expected, owing to the great diversity of designs of combustion chamber and makes of engine. However, certain clear tendencies can be traced, and the author goes so far as to suggest that, in general, the points lying closest to the mean curves are those corresponding to the engines which give the best fuel consumption.

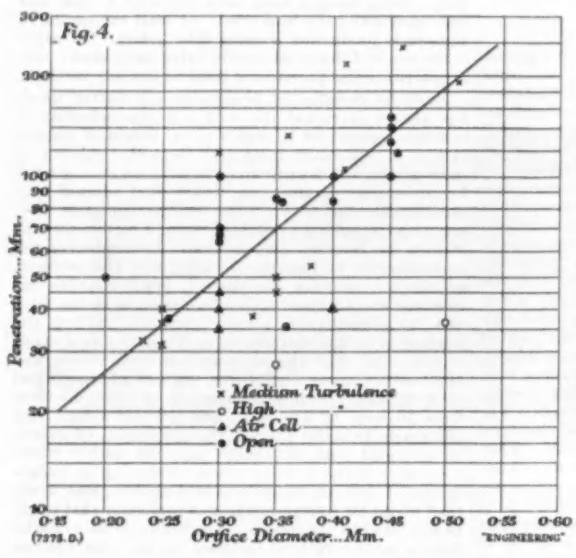
Since the combustion chamber is the essential part of any internal combustion engine, to which all the other parts may be regarded as accessories, a word must be said about combustion chambers. Apart from shape, the most significant feature from the fuel injection point of view is the degree of turbulence. Turbulence of the charge, when present, is always produced by causing the air at some part of the cycle to flow through a restriction at a high velocity. The author therefore finds it convenient in this connection to classify combustion chambers as follows :—Type 1. Open or non-turbulent chambers in which there is no special means to produce turbulence. Type 2. Medium-turbulence chambers in which the degree of turbulence is limited by the breathing capacity of the engine. In such chambers the restriction causing the turbulence is placed in the path of the incoming air, and if the restriction is too small it will reduce the volumetric efficiency unduly. Type 3. High-turbulence chambers in which the restriction is not placed in the path of the incoming air and in which the degree of turbulence is therefore not limited by the question of volumetric efficiency. Type 4. Special chambers (antechambers, air cells, etc.). The classification is, of course, largely arbitrary. There are probably no chambers which are strictly non-turbulent. "Squish" turbulence (as it has been called by Mr. Ricardo) produced by the close approach of the piston crown to the under side of the cylinder head is increasing in popularity. It has the advantage that the restriction is only present at that part of the cycle at which it is required. Combustion chambers employing this method should logically be classed as type 3, but they seemed to fall more naturally into type 2.

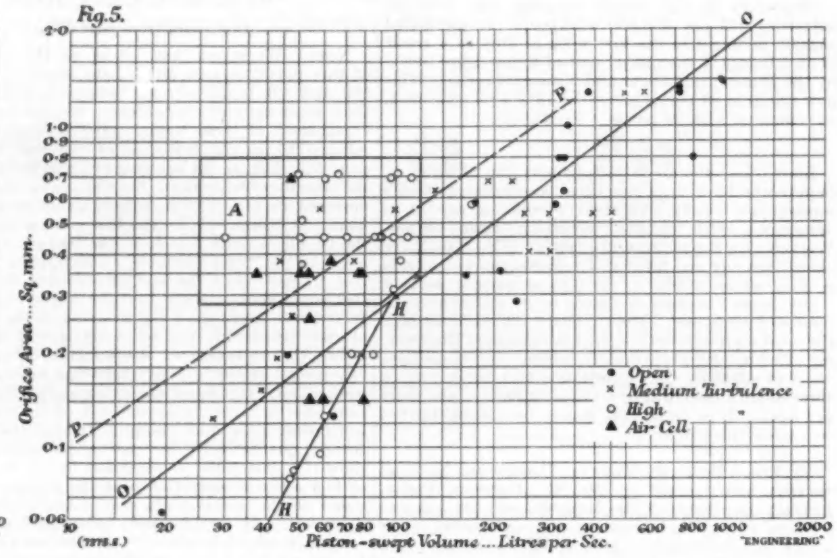
In combustion chambers of type 1 the fuel has to "seek out the air," whereas in chambers of type 3 the air seeks the fuel. In type 2 an intermediate state exists. In chambers of type 1 the spray must fit the chamber, and for this reason hole type nozzles are usually essential. The commonest form of open chamber is one that is approximately disc-shaped with the nozzle on the axis. This arrangement calls for a series of holes in the nozzle lying on the surface of a cone of wide angle. In selecting a nozzle for such a chamber the first point to be considered is the penetration of the spray. The size of hole and the pressure of injection must be such that the issuing fuel is able to penetrate all the air lying in its path up to the chamber wall. The penetration is controlled primarily by the diameter of the orifice holes. The results of many researches dealing with spray penetration have been published, but, as far as the author knows, none of

* Paper read before the Institution of Mechanical Engineers on Friday, April 26, 1940. Abridged.

† "Trapped pressure" is the residual pressure in the delivery pipe after the end of injection.

FUEL INJECTION IN OIL ENGINES.

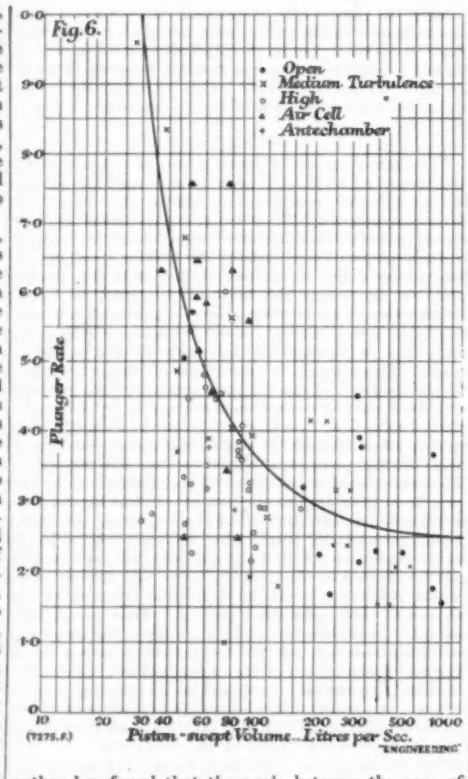




them has given the data required by the engine builder, as they have not been carried out under engine conditions. The kind of penetration that interests the engine builder is the distance that the spray travels, under the conditions within the combustion chamber, before it has all been consumed, or converted to a form in which it can be consumed without causing carbon deposits on the chamber walls. The author has, therefore, taken the useful or effective penetration as the distance from the nozzle along the axis of the spray to the wall of the combustion chamber, with the piston on its top dead centre.

The first of the curves referred to above, Fig. 4, relates the penetration, as defined in the previous paragraph, to the diameter of the orifice hole in the nozzle. This curve covers all types of combustion chambers in which hole type nozzles are used. The points from the individual engines are plotted and the degree of scattering can be seen. A line is drawn which the author regards as the mean. In deciding the position of this line he has "weighted" the plotted points in accordance with his views as to the merits of the individual designs which they represent. He puts forward this line as a basis for the selection of orifice diameter. In small engines using masked air valves with open chambers (type 2), the hole size appears to be greater than would correspond to a quiescent open chamber without a masked valve. This is to be expected, since the actual path of the spray is deflected by the air swirl and thus lengthened. In engines of what is often called the "clerestory" type, the penetration required is relatively greater than in type 1. Such engines of which the author has been able to get details employ correspondingly larger nozzle orifices, but the figures are vitiated to some extent by the fact that there are other special features about the injection equipment which may affect the result. In order that the fuel may be injected in a reasonable time and under a reasonable injection pressure, the total orifice area must bear some relation to the size of cylinder. In order to demonstrate this point, Fig. 5 has been plotted, relating the total orifice area to the volume swept by the piston in unit time. In this diagram, all points within the rectangular area A represent pintle nozzles. All other points represent hole type nozzles. "Piston-swept volume" is calculated as (mean piston speed) × (piston area) and is expressed in litres per second. This figure constitutes a measure of the rate at which air can be presented by the engine to the nozzle in the combustion chamber, and therefore it is a measure of the rate at which fuel should be delivered. It will be seen that the mean lines which have been drawn are straight, and although they are not straight when plotted on evenly divided paper they are sufficiently nearly so to indicate an approach to proportionality. The lines are not true means of all the points since many of the latter have been "weighted," in a similar manner to the points in Fig. 4. The longest line O O refers to chambers of types 1 and 2 (open and medium turbulence), whilst line H H refers to chambers types 3 and 4 (high turbulence and air cell) which are not used on the larger engines. Pintle nozzles will be referred to later.

Having estimated from these diagrams the size of hole and the total area, the number of holes, in the case of hole-type nozzles, is settled. Other points, however, must be taken into consideration. The



author has found that the angle between the axes of adjacent holes should not be less than about 20 deg. or more than about 45 deg. In the case of open chambers of type 1, without air swirl, which require a fairly flat conical disposition of the holes, this means that the number of holes cannot be less than about eight and the author has found in several cases that eight is definitely the best number. There are, however, a number of engines running with as few as five holes, and from this it appears that the best number of holes may be dependent partly on the question of the duration of injection. At low piston speeds, the fuel can be injected in the necessary time through a smaller number of holes than are necessary at higher piston speeds. In the case of the engines plotted here, the piston speeds are all in excess of 1,000 ft. per minute, except for a few of the very small ones. With nozzles of this type a central hole is sometimes placed on the axis of the nozzle. The penetration required from this hole is usually less than from the side ones, and it should, therefore, be smaller. The author has never obtained any advantage from the use of such a hole and he doubts whether it should be used except, perhaps, at extra high piston speeds.

Engines of type 2 which embody an open chamber and a masked air valve, use nozzles with from two to four holes, according to the degree of swirl. As mentioned above, this enables a larger hole to be used than would be possible in a non-turbulent chamber. This is advantageous in that it avoids the use of a large number of very small holes. In the case of chambers other than the open type, the number and disposition of the holes is settled fairly closely by the design of the chamber. In chambers of the clerestory type (type 2) the spray is often fan-shaped and has several jets in one plane. The angle between adjacent jets is then apt to be restricted and it may be difficult to maintain the minimum angle of 20 deg. mentioned above. Having obtained a certain amount of guidance up to this point, the remaining characteristics are a matter for trial guided by experience. Indeed, it may be found that the data given here serve rather as a check to the experience of the designer than as a guide from which to initiate design.

To find a logical basis for the selection of the best type of pintle nozzle for a given engine is much more difficult than in the case of the hole type. This is probably accounted for partly by the fact that in the case of nozzles available on the market the orifice area varies as the needle lifts and is, moreover, to a great extent bound up with the angle of divergence of the spray. Fig. 5 includes points which represent the orifice area of pintle nozzles plotted against the piston-swept volume. It is a notable fact that the points do not overlap those for hole-type nozzles in a single instance, but all lie within the area indicated on the diagram. The orifice area taken for each nozzle is that at the needle lift which gives the maximum. For the nozzles shown in Fig. 1, page 593, *ante*, it is at full lift, and for others at a partial lift. It will be seen that the points are so distributed that no mean line can fairly be drawn through them. The author suggests that the explanation lies in the two facts mentioned above. Where a combustion chamber requires a particular angle of spray, the designer may be forced to select a nozzle with a larger orifice area than is necessary, in order to obtain the required spray angle. Fortunately, there seems to be little objection to this procedure since the nozzle automatically accommodates itself, the needle lifting only sufficiently to give the necessary orifice area. Following this argument, the author further suggests that the orifice area of a pintle nozzle, for a given case, must lie above a certain minimum value, such as indicated by the dotted line P P in Fig. 5. Since pintle nozzles are used almost exclusively in combustion chambers having medium or high turbulence (or special chambers), the selection of the best angle of divergence of the spray is connected with the degree and nature of the turbulence to such an extent that no general conclusions seem possible.

After settling the approximate details of a suitable nozzle, the right pump must be found to feed it. In this connection certain numerical relationships are used. These are:—(i) Plunger rate. This is the volume in cubic millimetres which is displaced by the fuel-pump plunger during the injection period per degree of crankshaft rotation, divided by the stroke volume of the cylinder in litres. It connects the rate of delivery of fuel to the size of engine, and as far as the author knows was first used by Messrs. Ricardo and Company, Limited. (ii) Loading figure. This is the fuel-pump plunger velocity in centimetres per second multiplied

by the ratio of the plunger area to the nozzle orifice area. It gives a nominal value of the discharge velocity from the nozzle, and thus an approximate measure of the pressure generated in the system. (iii) Nominal injection angle. This is the angle of crankshaft rotation required to cause the fuel-pump plunger to displace a volume equal to that of the fuel injected at each cycle at the rated load of the engine. The most useful figure to plot as regards the pump is plunger rate. This is plotted against piston-swept volume in Fig. 6, on the opposite page.

There is a general tendency for the plunger rate to fall with increasing piston-swept volume and to settle to a value between 2 and 3. The need for a higher plunger rate on small engines is probably connected with the ratio of the trapped* volume to fuel per cycle.† This should always be kept as low as possible, and on big engines may with care be reduced to a value of 10 or even less. On small high-speed engines it approaches, or even exceeds, 100.

The author's experience, which he believes coincides with the general view, is that a small nominal injection angle is essential for good fuel consumption, but tends to produce rough running. He suggests 10 deg. as a suitable figure for highly rated engines using hole type nozzles. For engines using pintle nozzles, rather larger nominal injection angles prevail. The mean lies between 10 deg. and 20 deg., tending towards 10 deg. on the higher-rated engines. It will be found that, in order to keep the nominal injection angle within the limits recommended, it is often impossible to utilise the maximum output of certain well-known proprietary pumps. The size of pump to be fitted to a given engine is determined, not by the maximum capacity of the pump, but by the necessity for completing the delivery of fuel within a certain time. From this it follows that the full range of control of a pump is seldom used. If it were possible to start afresh, it might be better so to modify the design as to make the full range of control correspond to a smaller output. Such a step, however, is out of the question, since it would call for a corresponding alteration to the governor gear of all engines and would enormously complicate the question of spare parts and maintenance. The loading figure is intended to be a measure of the injection pressure, but it is unsatisfactory in so far as the actual injection pressure is affected very greatly by the trapped volume and by the duration of injection. It seems that normally, for hole type nozzles, the value of 35,000 should not be greatly exceeded and that for the best results the value should not be very far short of 30,000. Loading figures for pintle nozzles (calculated on the maximum orifice area) are much lower than for the hole type of nozzle. The normal value does not exceed 15,000.

It is sometimes a difficult question to determine the maximum capacity of an atomiser of given design in terms of rate of discharge of fuel. It has already been said that the fall of pressure must take place at the nozzle orifice and this implies that the minimum cross-sectional area occurring anywhere else in the path of the fuel must be large compared with that at the orifice. The point of minimum cross-section is usually at the needle seat. As the needle lift is usually small compared with the seat diameter and the width of the seat, due allowance must be made for the seat angle when calculating the effective cross-section. The author considers it desirable to maintain the area at the seat, if possible, not less than four times the orifice area, though he knows of cases giving good results in which the ratio is as low as 2·5. On account of strength considerations the seat must have a finite width, and the significance of the ratio of the needle seat diameter to the needle guide diameter has been explained already. These two factors, combined with the figure mentioned in the previous paragraph, determine fairly closely the minimum size of atomiser suitable to accommodate an orifice of given area. This appears to be the correct criterion of atomiser capacity.

The selection of the best release pressures for a particular engine does not seem to be a matter of primary importance, but it appears to be determined to some extent by personal preference. With pintle nozzles it usually lies between 1,000 lb. and 1,800 lb. per square inch, but the author has not enough experience to express any preference. With hole type nozzles, the value is seldom below 1,500 lb. per square inch, and is taken as high as 4,500 lb. per square inch. The author has not found much advantage in going above 2,000 lb. or 2,500 lb. per square inch. A high release pressure with hole type nozzles undoubtedly tends to produce rough running, and, other things being equal, generally results in a small improvement in fuel consumption. It might be expected that an increase in release pressure would not greatly affect the maximum injection pressure, but this is not so. An increase in release pressure usually results in a corresponding increase of pressure in the injection system throughout the cycle. Maximum injection pressures vary very widely. In systems using pintle nozzles they may not greatly exceed the release pressure. On the other hand, with hole type nozzles in engines of medium and large size, pressures as high as 8,000 lb. to 10,000 lb. per square inch are reached. There is no difficulty in dealing with such pressures in suitably designed equipment. High pressures tend to increase the penetration slightly and to improve atomisation, but the controlling factor as regards penetration is the diameter of the orifice hole. In the author's view, the injection pressure is not one of the primary variables. He prefers to regard it as dependent on other more vital factors.

* "Trapped volume" is the volume of fuel trapped between the fuel pump delivery valve and the nozzle needle valve.

† "Fuel per cycle" is the volume of fuel injected at each cycle at the rated load of the engine.

PROGRESS IN FEED-WATER TREATMENT.*

By C. H. FELLOWS.

(*Concluded from page* 602.)

TREATMENT to control either the extent of carry-over or its nature is not as effective in some cases as it should be. Much work has been done on the subject by Foulk, Brill, and Ulmer at the Ohio State University, and at the University of Illinois by Straub and his associates. At Ohio State, the foam-producing and carry-over characteristics of boiler waters, as affected by various concentrations of typical salts found in them, have been determined. This work, as summarised by Foulk and Ulmer, indicates that, of the commonly found soluble salts in boiler water, sodium phosphate, calculated as an anhydrous salt, produces carry-over at lower concentrations than the other salts. On the other hand, sodium aluminate, if it were in true solution, could be present in concentrations equal to twice that of the phosphate salt before carry-over would occur. When expressed in terms of equivalent sodium-chloride effect, it is reported that the effect on carry-over of all soluble salts is additive. In regard to suspended solids in boiler water, these same investigators conclude that certain ratios of calcium carbonate and magnesium hydroxide may exist in concentrations more than twice as great as magnesium hydroxide alone in the presence of sodium hydroxide before carry-over begins. In all cases, the physical state of the precipitated solids was found to be a controlling factor.

Professor Straub has proposed to control the nature of carry-over by counteracting the sticky quality of sodium-hydroxide deposits with sodium sulphate. His work indicates that if a ratio of 4·4 to 1, sodium sulphate to sodium hydroxide, respectively, is maintained in the boiler water, adherent deposits will not occur. A survey of a number of power-plant records of boiler-water conditions served to indicate that adherent deposits on turbine blades, a result of carry-over, were not in all cases a function of the proposed ratio of 4·4. In certain cases, however, where this ratio has been intentionally maintained for this purpose, successful inhibition of adherent deposits in the case of carry-over has been realised. Steam washers are being used with considerable reported success to prevent carry-over of water into the steam space. Even in the case of the use of such steam washers, the power-plant chemist attempts to control foaming by maintenance of proper concentrations of dissolved and suspended solids.

The application of our knowledge of feed-water treatment to any specific job requires the balancing of the effects produced by the several available processes with the conditions known to exist, as well as with those that may possibly exist in the normal course of operating boilers and steam-consuming equipment. For example, in a plant operating on a condensing cycle and supplied with evaporated make-up there would seem to be little fear of scale formation, and any treatment required should be designed only to prevent corrosion, carry-over and possibly the development of embrittlement. In some cases, depending upon the likelihood of condenser leakage and upon the nature of the cooling water, a small amount of scale may form. In the high-pressure type of boiler, even a small amount of scale is dangerous and sound treatment should guarantee protection in the event of such leakage.

Another case applicable to the same type of boiler equipment concerns the choice of methods to protect against embrittlement. If the boiler feed-water is so free of dissolved alkali-producing salts that the desirable *p*H range of 10·5 to 11 is not attained and, as a result, conditions more favourable to corrosion exist, it may be necessary to add an alkaline salt to the water. From this consideration arises the question of protection against embrittlement, and the natural procedure would be to add sodium sulphate. However, the presence of the sulphate ion in the water, together with the possibility of leaky condensers admitting raw water containing scale-forming salts, would make the chance for the deposition of hard scale highly favourable, and further treatment would be necessary to counteract that tendency. The early work of Professor Straub, recently further substantiated, indicated that the phosphate ion in proper concentration was capable of preventing embrittlement at pressures up to roughly 400 lb. per square inch gauge. The logical treatment of this situation would be, therefore, to inhibit the development of embrittlement with phosphate, which can be maintained in excess of that value necessary to remove the scale-forming salts from the water; thus, two additions only are necessary instead of three.

The effectiveness of any treatment will be greatly enhanced by the judicious use of coagulants to flocculate the precipitated and suspended solids. Perhaps the most widely known chemical compound used for this purpose is sodium aluminate, and organic compounds have been used successfully in this respect. An example of well-designed experimental treatment based upon sound theoretical considerations, for a boiler operating at 1,200 lb. per square inch and using distilled water with a low proportion of evaporated make-up, is as follows: the treatment is designed to prevent scale, corrosion, and embrittlement. Scale is prevented by the use of phosphate, but an excess of the phosphate ion is not maintained, thus permitting a slight residual hardness in the water. This is done deliberately to reduce the possibility of carry-over and to provide calcium ions with which, in the presence of colloidal iron, silica will combine and be prevented from entering into those reactions which, in combination with caustic, have been shown to cause embrittlement. Colloidal iron is used primarily as an oxygen scavenger. Although its economy for this use alone might be questioned, it is justified because silica removal is necessary. R_2O_3 is also added as an embrittlement preventive at the high operating temperatures prevailing. Although carry-over is not anticipated and has not been encountered in the several months of operation of this unit, the complete removal of silica by both R_2O_3 and the calcium precipitation insure no adherent deposits on blades if carry-over did occur.

"Is it necessary to treat to prevent embrittlement in high-pressure boilers?" is a question frequently asked in the power-station industry. It is evident that this question would not be asked unless some difficulty has been encountered in the attempts to treat the water in accordance with prescribed recommendations. The assumed value of the A.S.M.E. ratio of sodium sulphate to total alkalinity for this purpose has become so firmly established that any plan of feed-water or boiler-water treatment automatically includes, where necessary, the addition of enough sulphate ions to maintain that ratio. The question is undoubtedly prompted by two considerations; caustic embrittlement has not been encountered as yet in high-pressure boilers, and many operators of high-pressure boilers find it impossible to maintain those ratios without inducing foaming and subsequent carry-over.

In general, it has been found that, where the maintenance of this ratio has been attempted, such a high concentration of dissolved solids in the water has resulted that it was impossible to operate without violent carry-over. As a result, the ratios in most cases were not maintained. Necessity has demanded operation in a manner contrary to accepted rules, yet no dire effects have been the result. A number of explanations may be offered. Among these are the welded construction of these high-pressure units, which precludes the possibility of seams and crevices in which boiler water may concentrate to such values as from 50,000 parts to 100,000 parts per million of sodium hydroxide necessary to induce intercrystalline corrosion. Another reason may be related to the findings of the recent research efforts at the United States Bureau of Mines and at the University of Illinois, wherein it has been indicated that the A.S.M.E. ratios are not, under all conditions, adequate to stop this type of cracking, and therefore the factors that cause embrittlement are not those which are uniformly combated by this salt. Stress relieving also reduced the possibility of highly stressed metal, another necessary factor in the development of this phenomenon.

Regardless of what the real reason may be, there is a great deal of operating experience that indicates no evidence of embrittlement under high-pressure conditions where the ratios are not maintained. A subcommittee of chemists, functioning under the A.S.M.E. Boiler Code Committee, is at present reviewing operating data and relating it to the recent findings of research on this subject in an effort to modify the code recommendations in order to bring them in line with present knowledge.

* Paper presented at the Spring Meeting of the American Society of Mechanical Engineers at Worcester, Massachusetts, U.S.A., May 1 to 3, 1940. Abridged.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the communicators are given in italics.

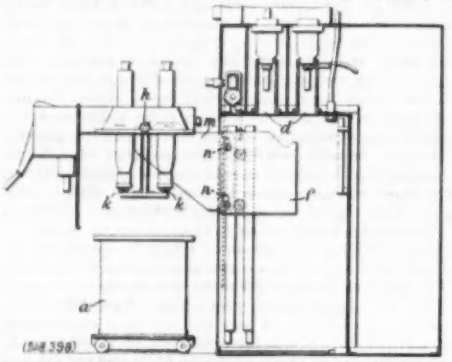
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

518,398. Metal-Clad Circuit Breaker. Switchgear and Cowans, Limited, of Old Trafford, and A. Upton, of Manchester. (2 *Figs.*) September 26, 1938.—The circuit breaker is arranged so that its contacts and their mechanism are easily inspected. The breaker *a* is mounted upon a truck on which it is wheeled into position beneath the isolation receptacles *d* in the housing. Arms *f* at



each side of the housing are raised by chains to engage beneath projections *h* on the top plate of the breaker and lift it into its operating position. The truck can then be wheeled away, the space beneath the oil tank being used to house a potential or current transformer. To inspect the circuit breaker contacts *k*, the circuit breaker is lowered and wheeled forward in front of the housing. The top plate is released from the tank and detachable arms *m* are connected at *n* to the arms *f* of the elevating gear. The arms also engage beneath the projections *h* to raise the top plate and contacts clear of the oil tank, which can then be wheeled away. All sides of the contacts and mechanism are then available for inspection. (*Accepted February* 26, 1940.)

MOTOR ROAD VEHICLES.

519,236. Centrifugal Clutch. The Northern General Transport Company, Limited, of London, and G. W. Hayter, of Gateshead-on-Tyne. (4 *Figs.*) October 1, 1938.—The invention is a centrifugal clutch which can be disengaged by hand. The clutch-plate 4 is sandwiched between two pressure plates 5, 6. The first pressure plate 5 is guided on pins. Springs around the pins urge the plate away from the clutch-plate. The pressure plate 5 is moved in the opposite direction by centrifugal ball weights 10, each located in an inclined bore in the flywheel. When the flywheel rotates at above a given speed the balls displace the pressure plate against its springs. The extent of this displacement is limited by an abutment ring 12 on the rim of the flywheel. Springs 13, housed in cups on the end-plate, urge the pressure plate 6 towards the clutch-plate and are sufficiently strong to ensure driving engagement of the clutch. The pressure plate 6 can pass through the abutment ring 12 but is of greater diameter than the clutch-plate 4. In the overlapping portion are holes, through each of which projects a detent 15 pivoted on the end-plate. The detents are hooked and tend to move outwards against tension springs as soon as the flywheel rotates. Each hook is undercut slightly and co-operates with a corresponding face on the inside of the pressure plate 6 so that, once they are engaged, disengagement can only be effected by moving the pressure plate. The abutment ring 12 is located so that the pressure plate 5 cannot follow-up any movement of the pressure plate 6 away from the clutch-plate. The operation is as follows: The detents 15 are normally engaged as shown in Fig. 2, so that,

Fig. 1.

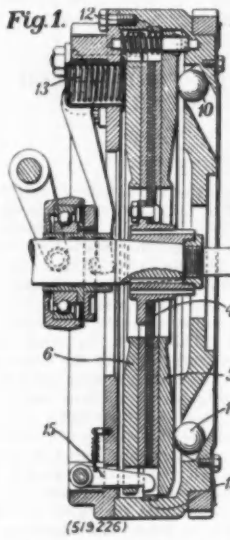
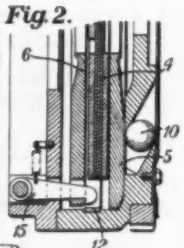


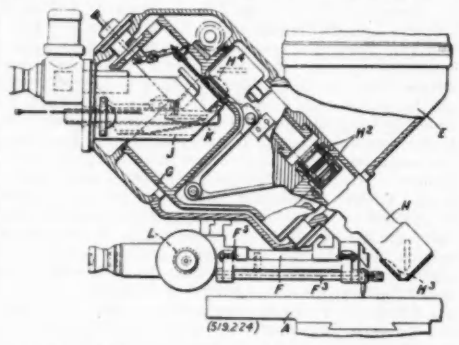
Fig. 2.



with the flywheel at rest, the clutch is disengaged. As the flywheel is speeded up, however, the balls 10 move out and wedge the pressure plate 5 against the clutch-plate, gripping the latter between the two pressure plates. Disengagement can be effected at will by a pedal to displace the pressure plate 6 away from the clutch plate, the pressure plate 5 being prevented from following-up by the ring 12. To engage the clutch while at rest, as when starting the engine by towing, the pressure plate 6 is moved slightly by the pedal until the detents 15 are freed by their springs. The release of the pedal then allows the pressure plate 6 to be moved by its engaging springs to grip the clutch-plate between it and the pressure plate 5. A drive may then be transmitted from the driven shaft to the engine. As the engine speed increases, the balls move both pressure plates until, when the pressure plate 6 has passed beyond the hooked ends of the detents 15, these automatically move out under centrifugal force, and upon slowing down the engine, the pressure plate 6 is held by the detents and the clutch is disengaged. (*Accepted March* 20, 1940.)

MISCELLANEOUS.

519,224. Optical Profile-Measuring Apparatus. Kapella, Limited, of Leicester, A. Warmisham, and R. E. Reason, of Leicester. (9 *Figs.*) November 30, 1938.—The apparatus is used for the precision measurement of plane section profiles of such articles as gearwheels or screw-threads. The apparatus has a fixed base which supports a work-table A which can be adjusted in three mutually perpendicular directions. Behind the table, the base carries a main horizontal shaft, the axis of which passes through a normal zero point over the work-table. The shaft forms the bearing for a hood which can be clamped in any position. The upper end of the hood carries a neck portion which, in turn, carries a rotatable optical head E, the axis of rotation of which intersects the axis of the main horizontal shaft at right angles at the zero point. The optical head E carries a detachable scribing unit F, and has within it a rotor G carrying the optical projection unit H and also a plate box J for the photographic plate. The projection unit H is made separate from the rotor G and is so mounted in the lower portion of the rotor as to enable its position to be adjusted with a high degree of accuracy. It houses the projecting lens system in which a central projecting lens H^2 is mounted symmetrically between two collimating lenses H^3, H^4, the principal focal points of which coincide with the nodal points of the projecting lens H^2, the arrangement giving a rectified image at unit magnification. Two plane mirrors at 45 deg. to the axis of the projecting lens deflect the optical axis through the two collimating lenses. The axis of the lower collimating lens H^3 intersects the scribing plane at 45 deg. at the same point as the axis of rotation of the rotor G. The image plane of the



projecting lens system passes through the point of intersection of the optical axis of the upper collimating lens H^4 and the axis of rotation of the rotor G and lies at 45 deg. to both axes, so that it is at right angles to the scribing plane. The plate box J has an opening through which a plate slide is inserted and when the shutter has been opened, the photographic plate K is sprung into engagement with fixed stops, which locate it accurately in the image plane of the projecting lens system. The scribing unit F has two similar scribers, arranged one on each side of the end of the casing. Each scriber is clamped to a crank arm on a spindle F^3 journalled in a frame pivoted at F^5 to the casing F so that the scriber can be moved by hand. The axes of the two spindles F^3 and of the two sets of pivots F^5 are all parallel to one another and to the longitudinal axis of the casing F, and the longitudinal position of the scribers is such that they move only in a plane which defines the section profile and constitutes the scribing plane. For illuminating the scribed mark, a lamp L is mounted in a housing and surrounded by a heat-insulating screen to avoid heat disturbance of the adjacent optical elements. A condenser gives a parallel, or slightly convergent, beam which, after reflection in an inclined mirror, is directed on to the scribed mark. The same condenser and mirror can be utilised in conjunction with an eyepiece and graticule for viewing the scribed mark, the lamp L being movable when the mark is to be viewed. When it is practicable to view the scribed mark at a relatively small inclination to the normal to the scribing plane, a wide-angle projecting lens can be used for the oblique projection with its nodal planes parallel to the scribing plane and the image plane. Such an arrangement can be employed for projecting an enlarged image on to a screen. (*Accepted March* 19, 1940.)

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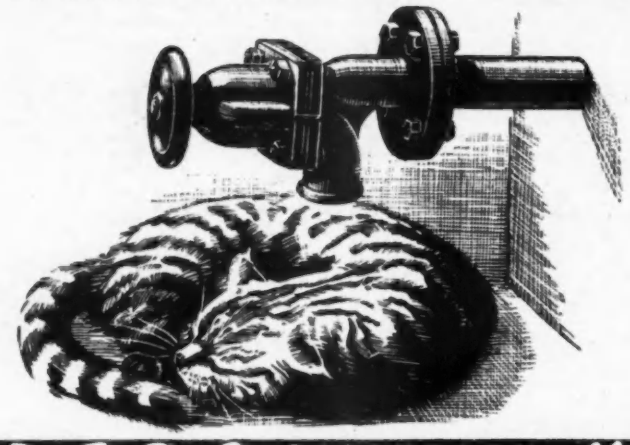

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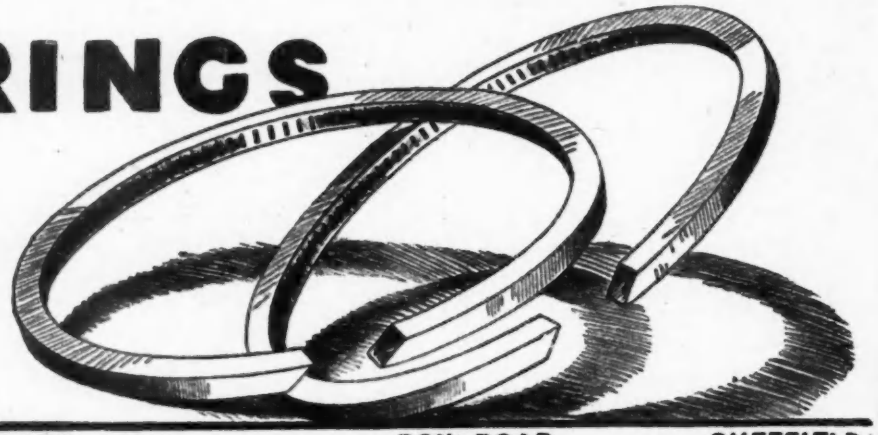

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	PAGE
Abbott & Co. (Newark), Ltd.	37
Adamson-Alliance Co., Ld.	42
Aerospray Manufng. Co., Ltd.	41
Alexander, Herbert & Co., Ltd.	44
Alldays & Onions, Ltd.	1
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Anderson, D., & Son, Ltd.	10
Armstrong Whitworth & Co. (Ironfounders), Ltd.	43
Arrol, Sir Wm., & Co., Ld.	31
Ash, Joseph, & Son, Ltd.	44
Ashworth, E. & A. Ltd.	49
Asquith, Wm., Ltd.	2
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Atlas Diesel Co., Ltd.	37
Automotive Eng'g. Co., Ltd.	35
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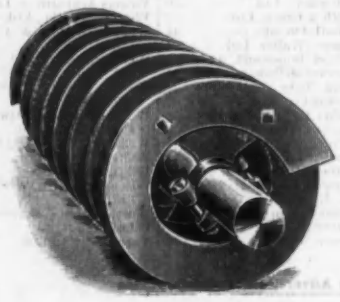

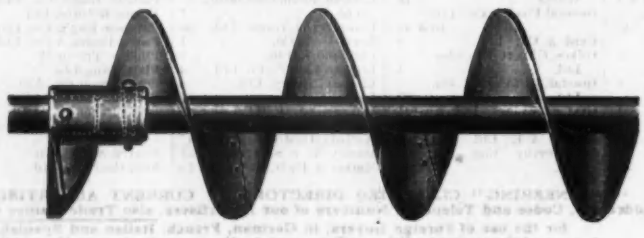

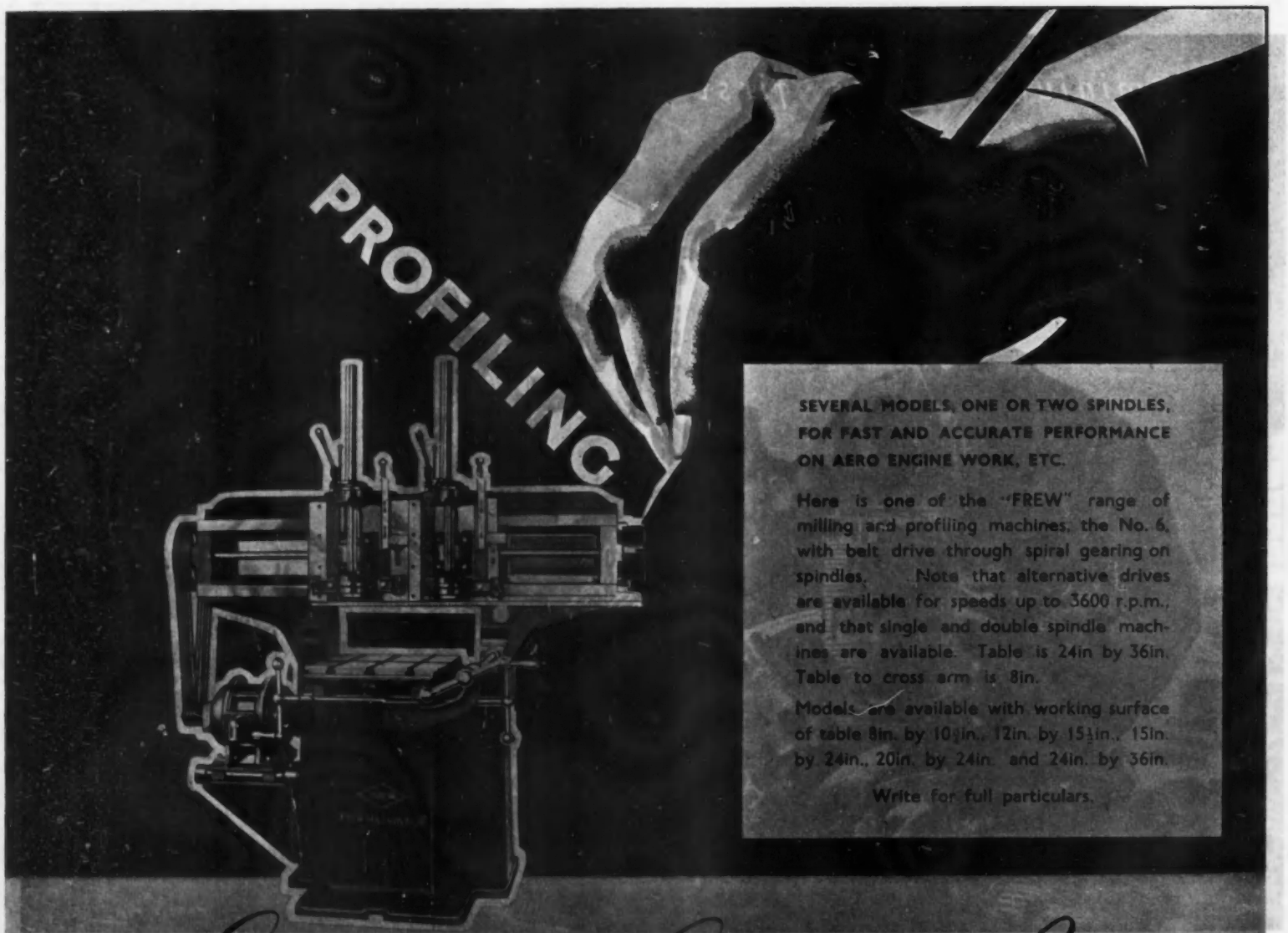

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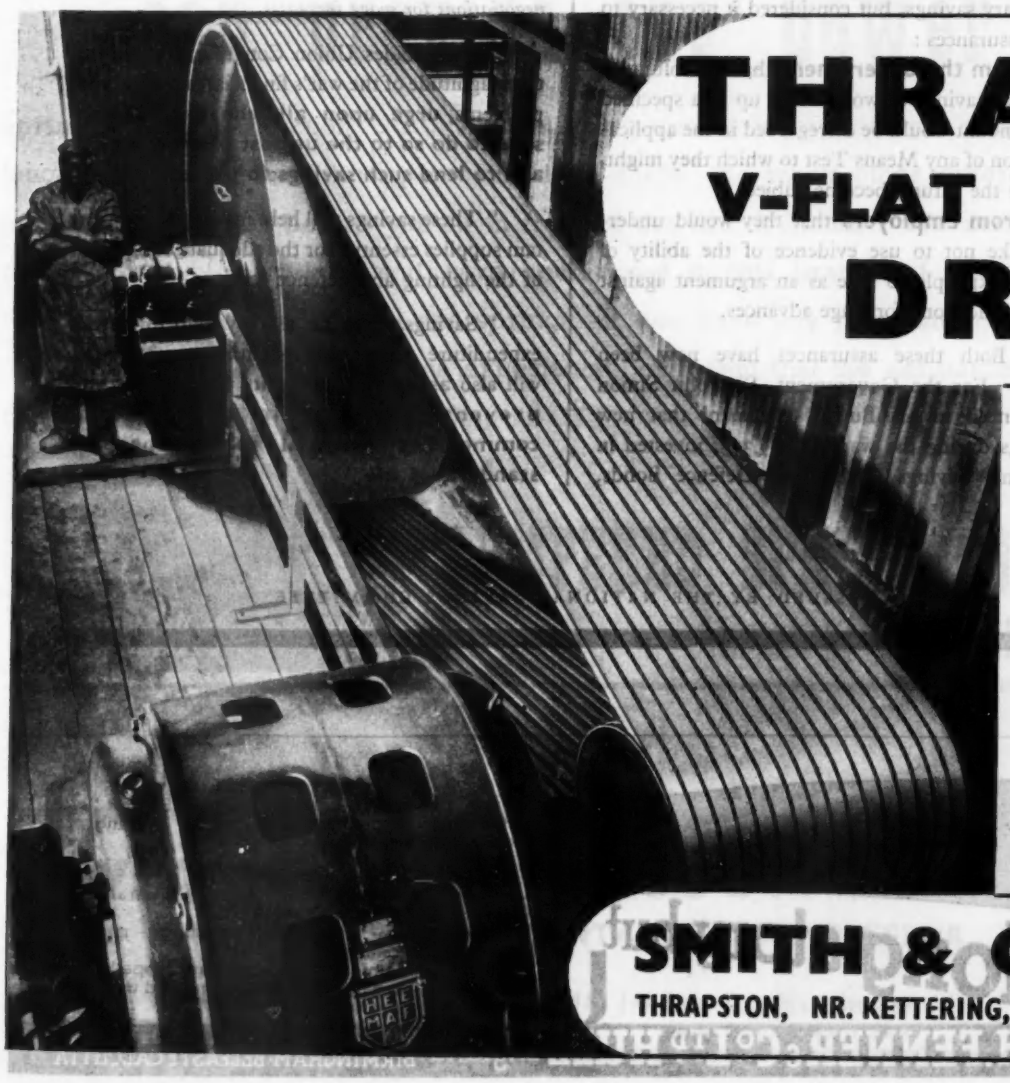

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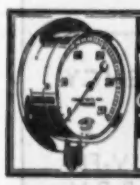

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"As a result, the General Council were anxious to give their full and strong support to voluntary savings, but considered it necessary to seek assurances :

(*a*) **From the Government** that the voluntary war savings of workpeople up to a specified amount would be disregarded in the application of any Means Test to which they might, in the future, become subject.

(*b*) **From Employers** that they would undertake not to use evidence of the ability of workpeople to save as an argument against applications for wage advances.

"Both these assurances have now been given. For the Government, Sir John Simon announced in his Budget statement that new savings during the war up to £375, invested in National Savings Certificates, Defence Bonds, subscriptions to new War Loans, or deposited in the Post Office Savings Bank or the Trustee Savings Banks *would be disregarded in computing the means of applicants for unemployment assistance or supplementary old age pensions.*

"The Employers have also given a definite assurance that *the war savings of workpeople will not be used against the Trade Unions in subsequent negotiations for wage increases.*

"The Trades Union Congress, recognising the magnitude of the war's financial and economic problems, **urge upon all who are able to save to do so to the utmost of their ability and to lend such savings to the country.**

"These savings will help materially to maintain supplies essential for the adequate equipment of the fighting and defence services.

"Savings, in so far as they help to restrict expenditure upon non-essential commodities, will also **assist to maintain the supply and prevent increases in the price of commodities essential to the people's standard of life.**"

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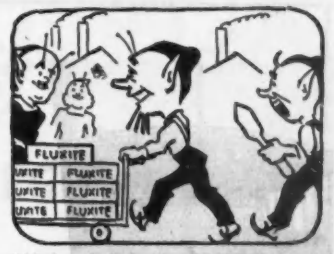

"Mind your backs there," cried "Oh" "I must speed,
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It's in boom times like these
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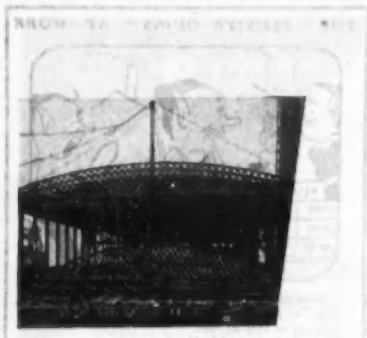

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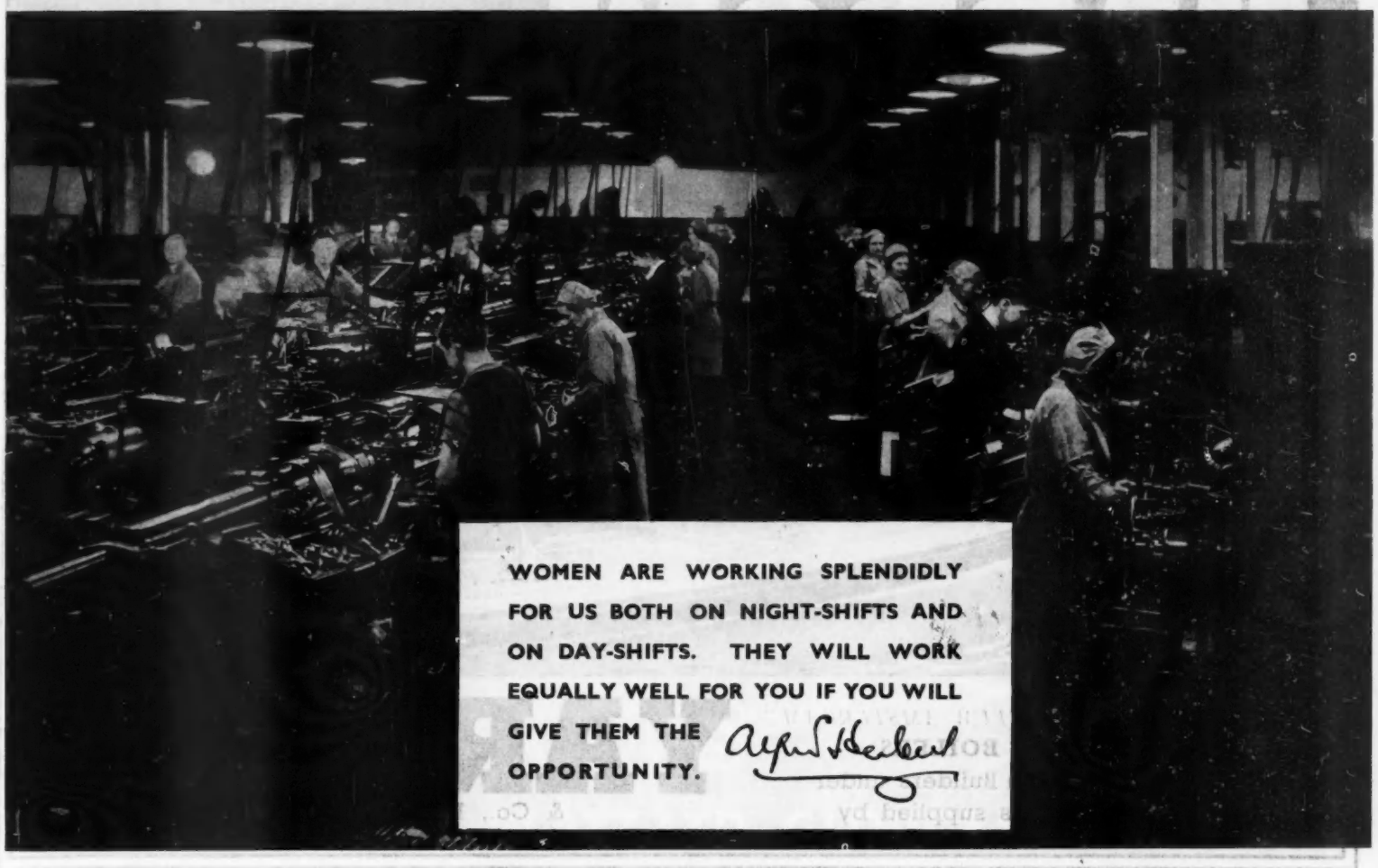
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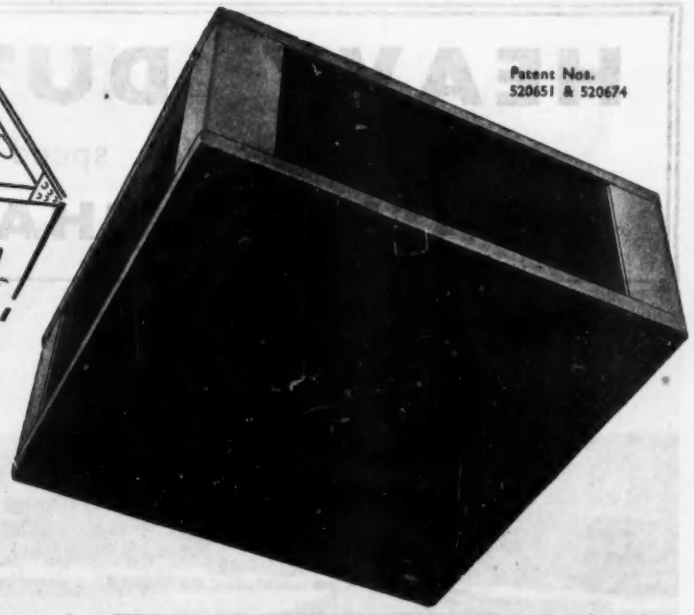

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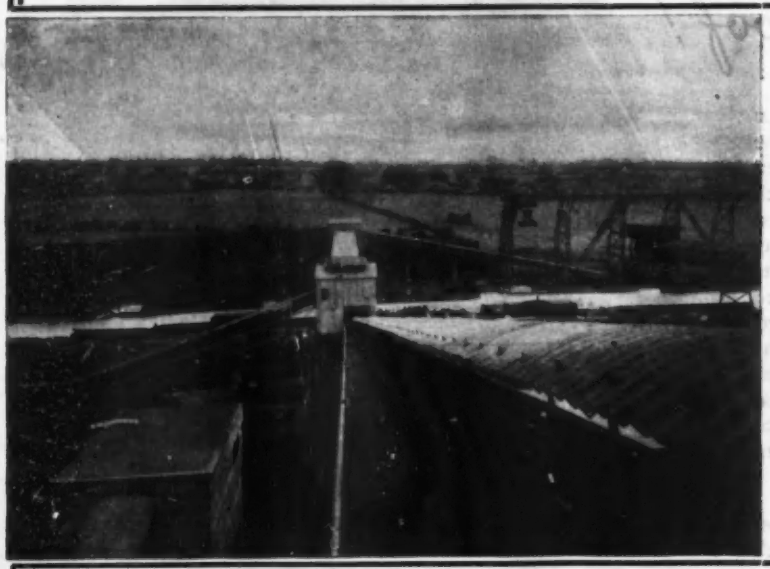

Speed up output is the order of the day.

This is a view of one of the many large Fraser & Chalmers Handling Plants which are playing an important part in the national effort.

Consult Fraser & Chalmers on all handling problems from complete plants of any capacity down to maintenance and replacement items for existing plants.

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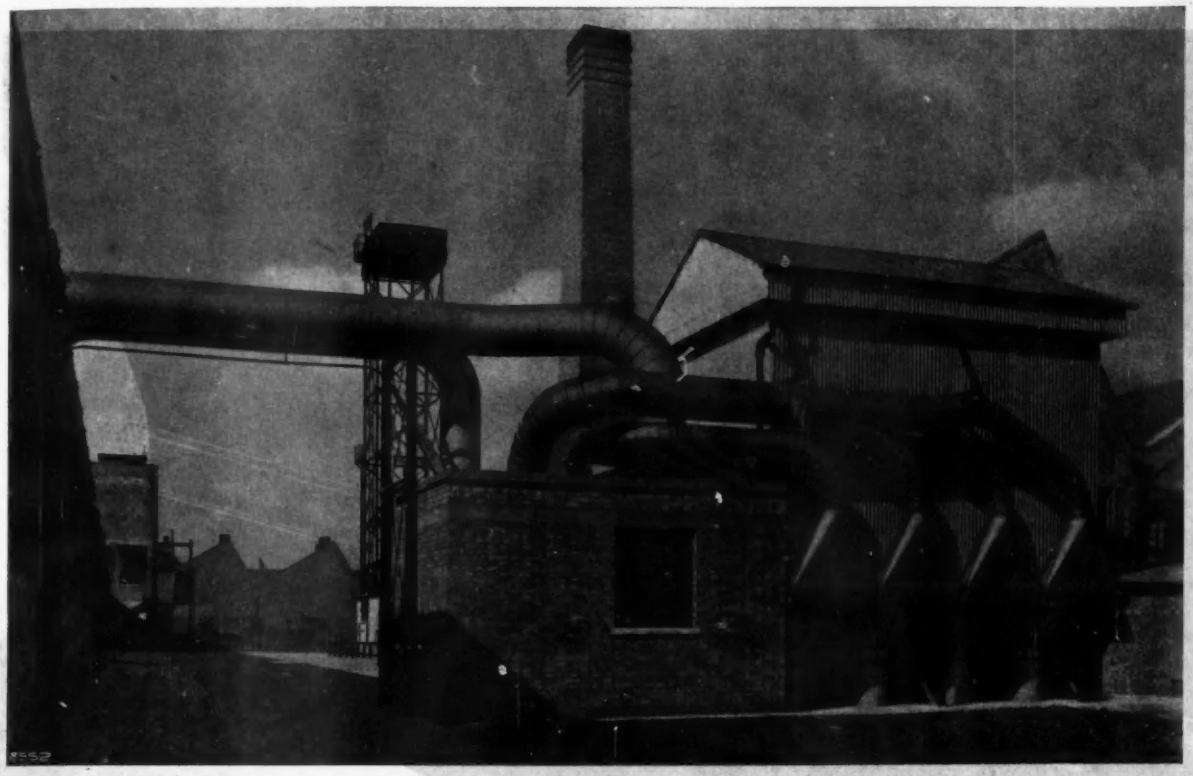

In this illustration is shown fans and bag filter equipment installed by us to handle refuse from 120 polishing heads. The small brick building houses two steel plate fans with their motors.

The air from these fans is discharged into bottom hopper type bag filters, there being 8 groups of 9 bags each, housed in the corrugated iron building alongside.

In order to facilitate the disposal of the refuse collected, each of the 8 hoppers discharges into a dustbin which can be seen in the illustration. These dustbins are easily removed, complete with their load, without the use of any special tools or appliances.

Photo by courtesy
"Power and Works Engineer"

STURTEVANT DUST COLLECTING

Particulars and illustrations are given in our post free publication D1101. 870

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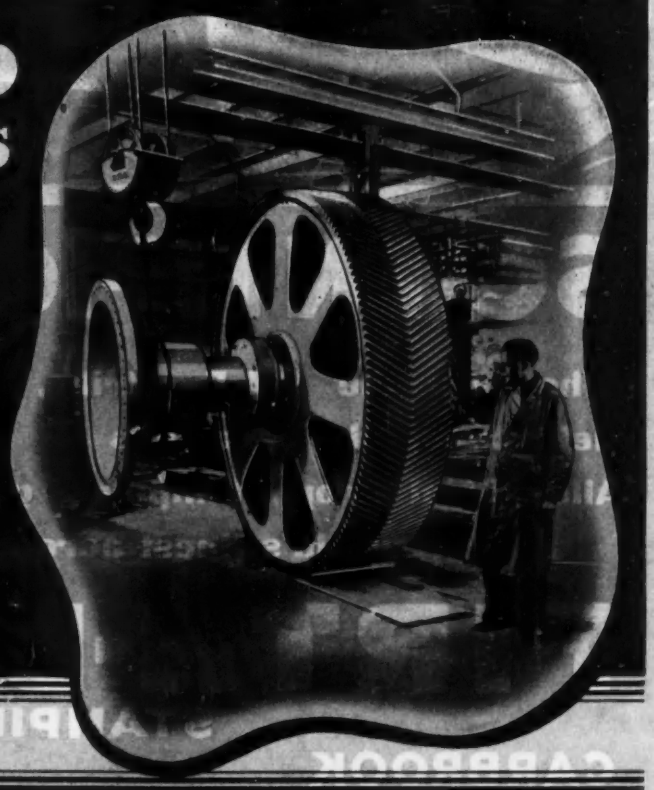
The second gear in the reduction unit for a cement mill, the normal power being transmitted is 800 h.p. with overloads.

This gear has continuous Double Helical Teeth cut on one of our 'No. 30 S.D.H. Sunderland Gear Planers which cuts Spur or Double Helical Gears up to 10 ft. diam. x 24" face 1 D.P.

By courtesy of Messrs. Turbine Gears Ltd., Cheadle Heath, Stockport.



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FIRTH-DERIHON
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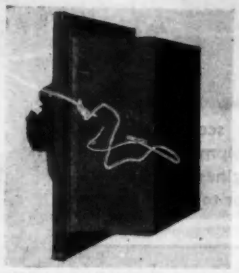
VENTILATING FANS

VARIOUS TYPES ALL SIZES

WITH BELT PULLEY OR ELECTRIC MOTOR



Where ventilation is required during blackout we recommend the use of our Anti-Glare Vents in conjunction with our Fans or existing ventilating plant. These Anti-Glare Vents prevent the escape of light and glare to the outside and at the same time permit maintenance of efficient ventilation.

A "Blackman" Ventilating Fan with "Buxton" Certificated Flame-proof Motor, as installed in Aeroplane Works, etc.

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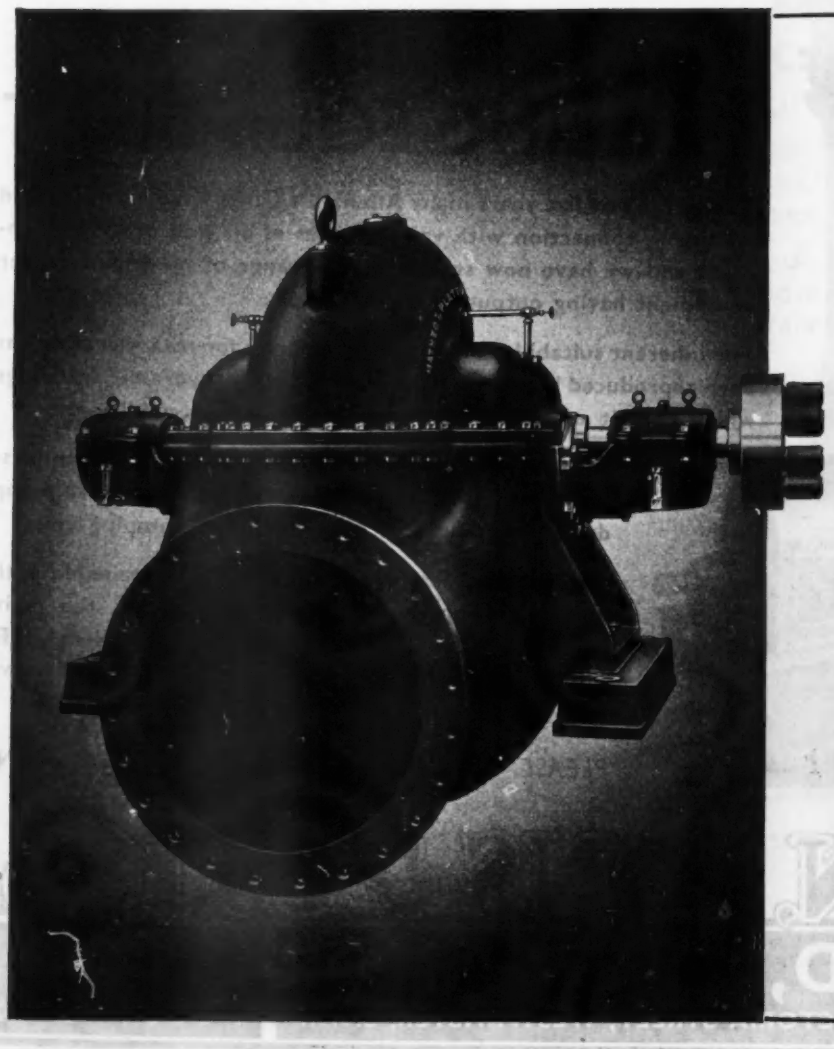

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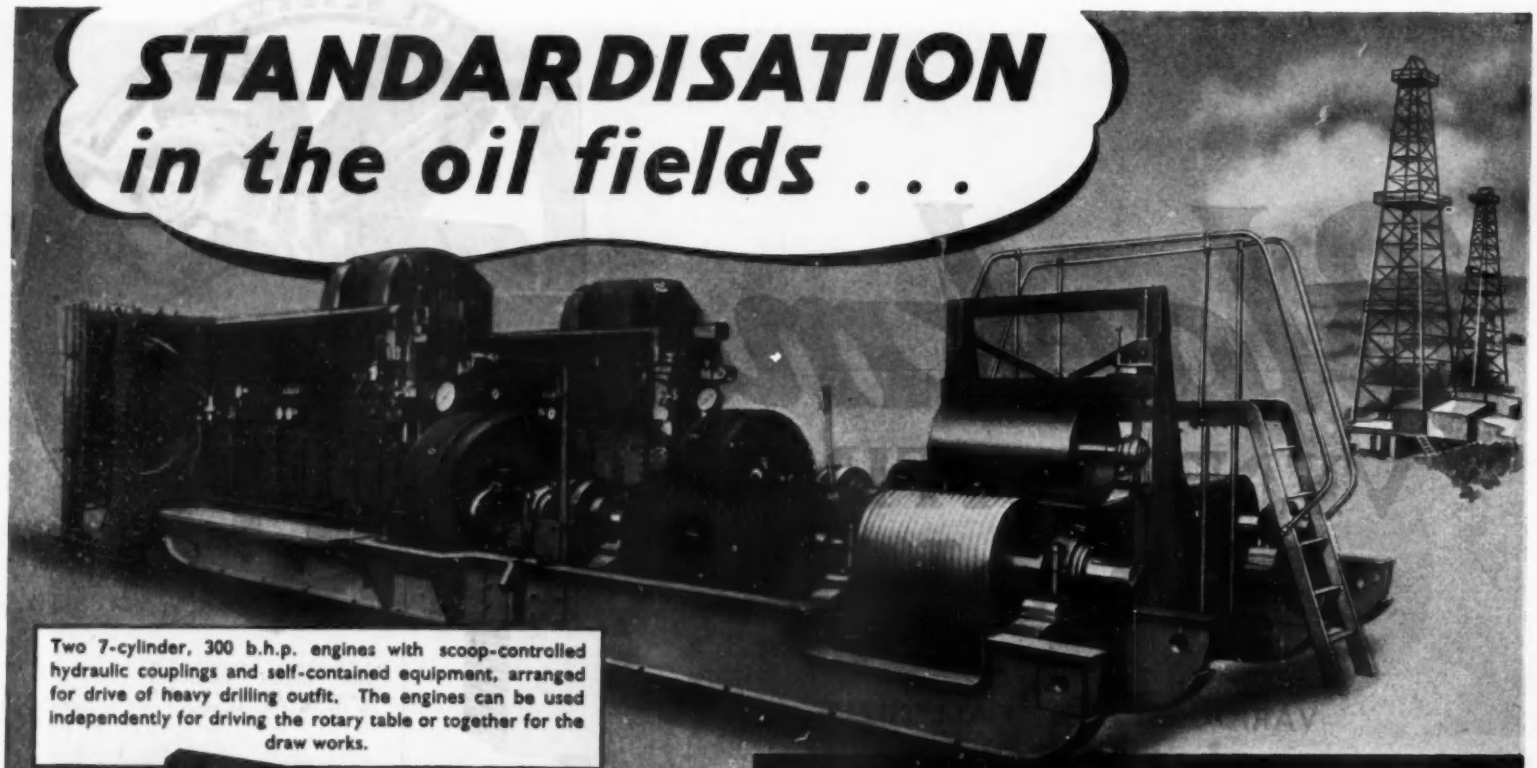
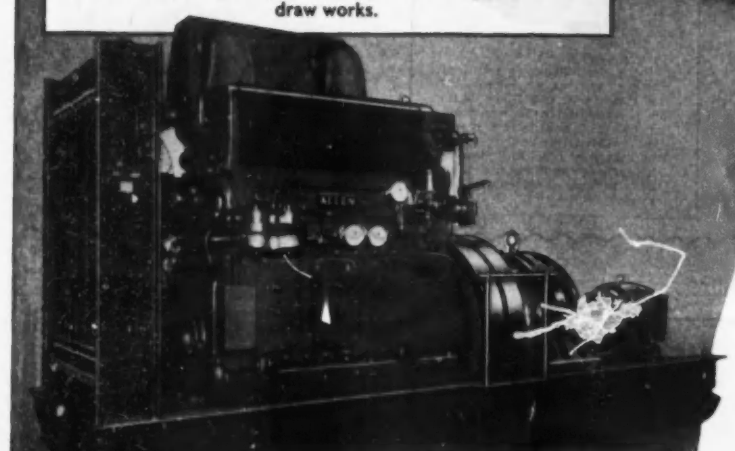
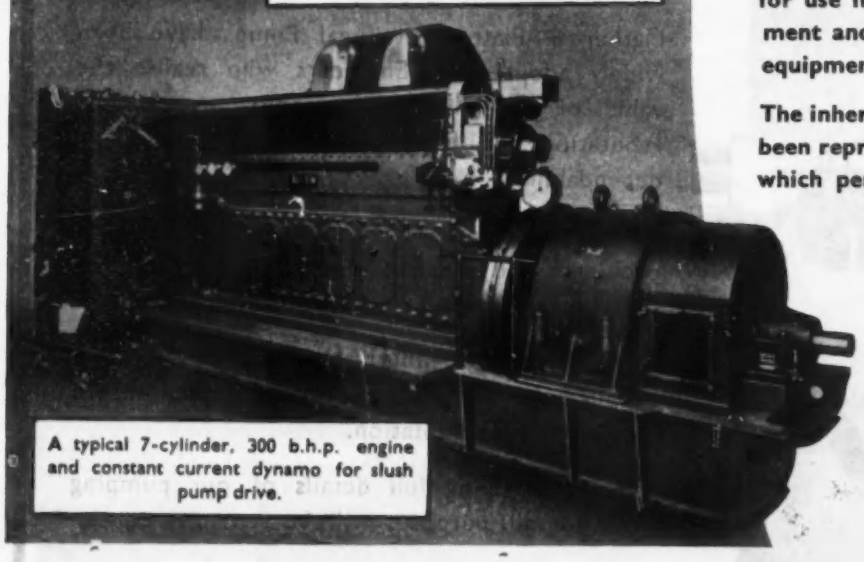


Two 7-cylinder, 300 b.h.p. engines with scoop-controlled hydraulic couplings and self-contained equipment, arranged for drive of heavy drilling outfit. The engines can be used independently for driving the rotary table or together for the draw works.



3-cylinder, 600 r.p.m., 130 b.h.p. engine and 75 kW. alternator for general purpose power generation.



A typical 7-cylinder, 300 b.h.p. engine and constant current dynamo for slush pump drive.

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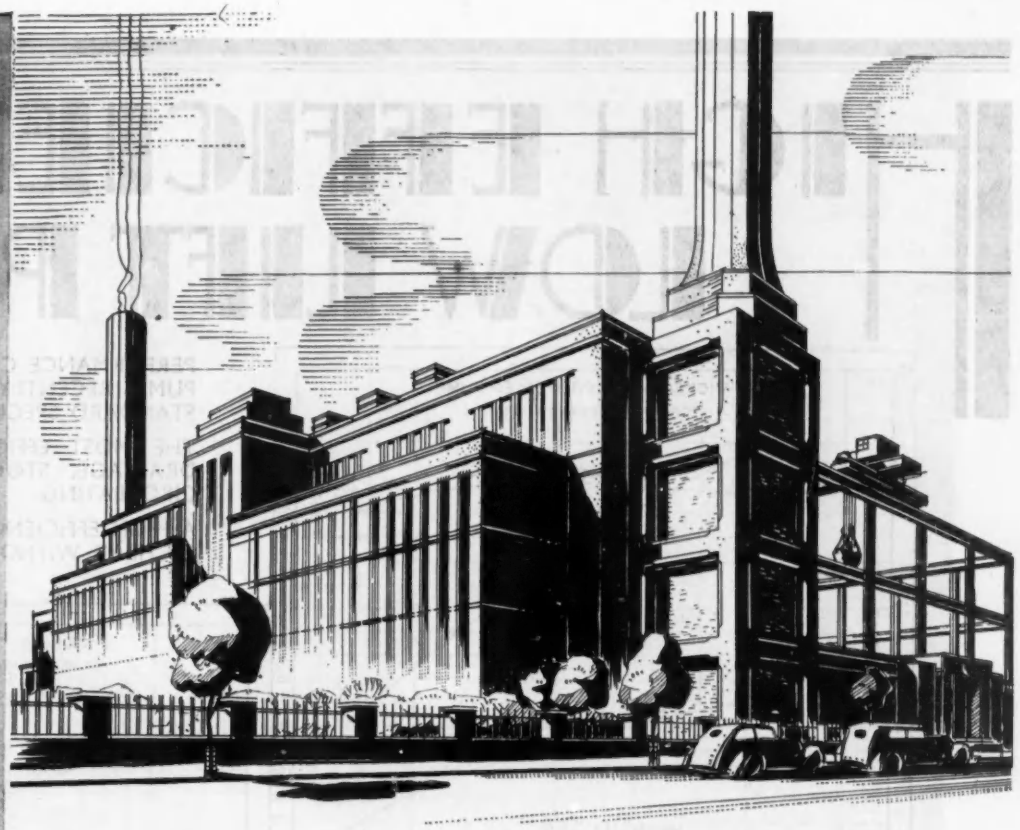

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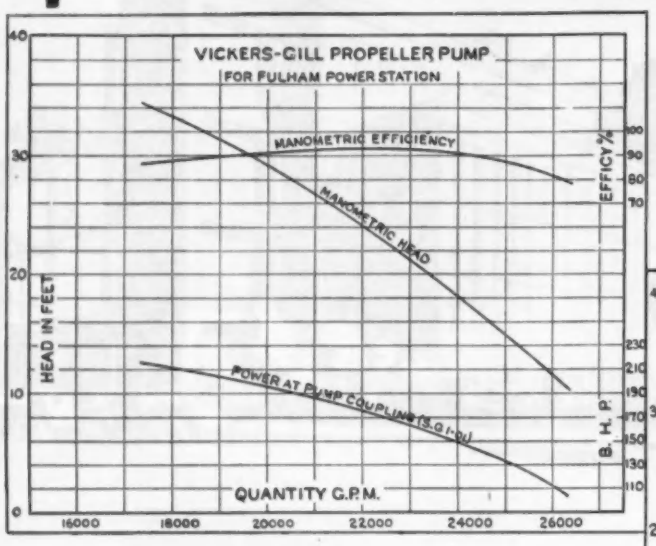

Two stage horizontal circulating water pump for Fulham Power Station.

Designed duty 22,000 G.P.M. against a Manometric head of 24 feet discharge branch 32 in. bore.

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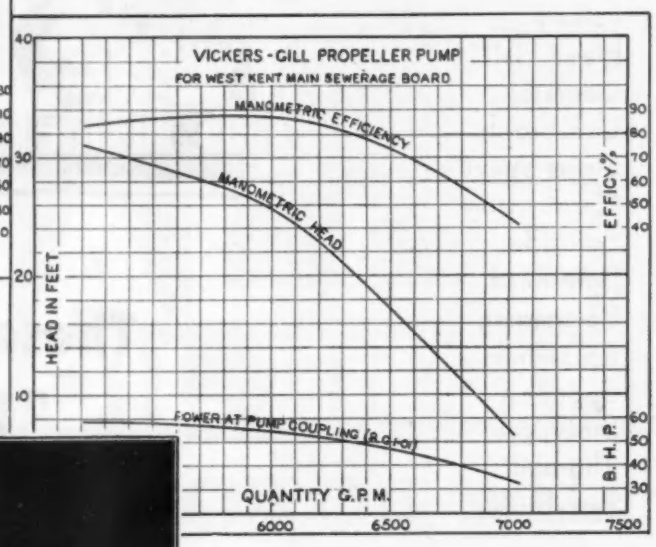

Single stage vertical pump for the West Kent Main Sewerage Board. Designed duty 6,000 G.P.M. against a Manometric head of 22 ft. discharge branch 18 in. bore.

The illustration on the left is a view taken from the sewage storage well of three 18 in. Vickers-Gill Propeller Pumps supplied to the West Kent Main Sewerage Board.

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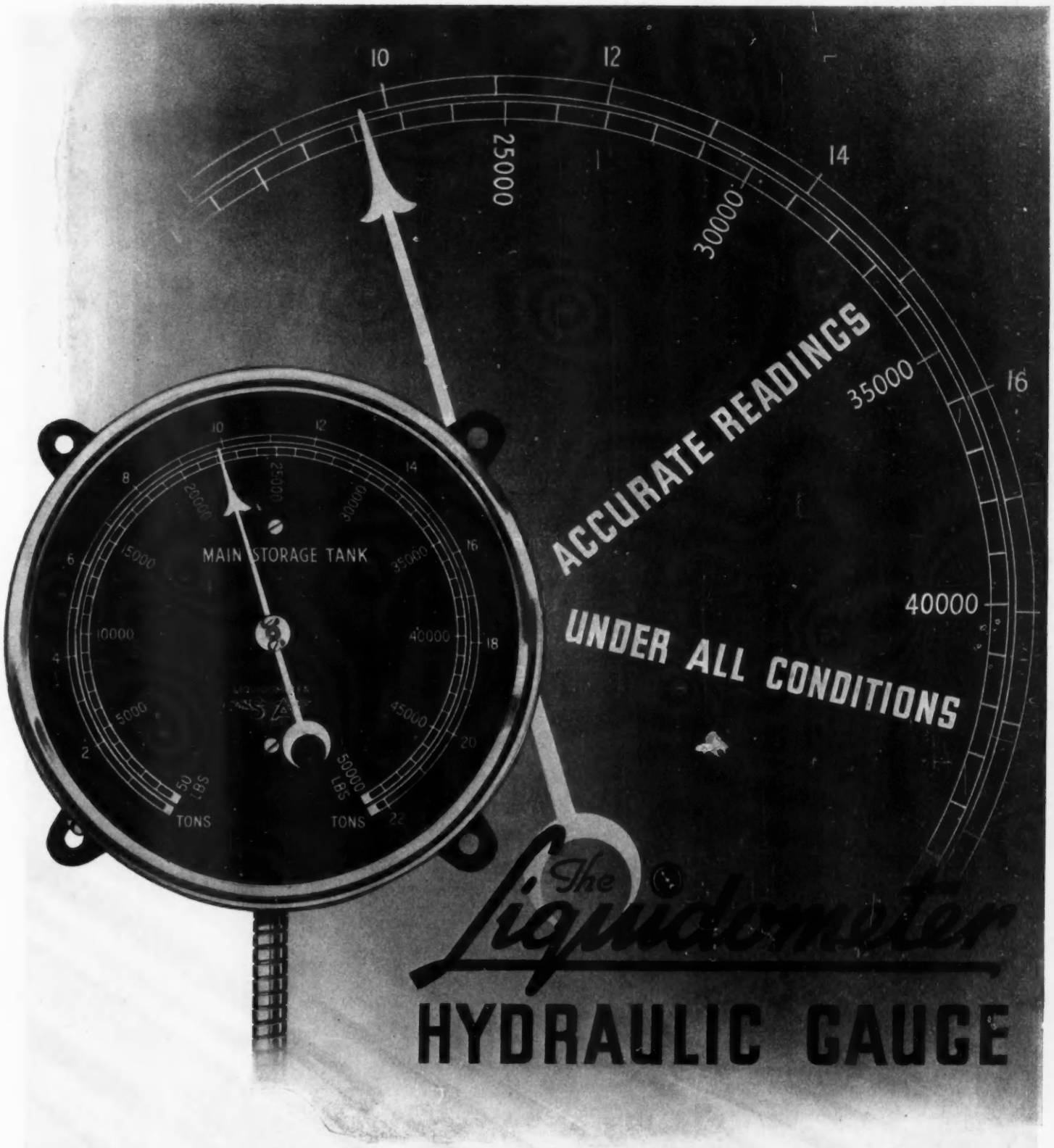

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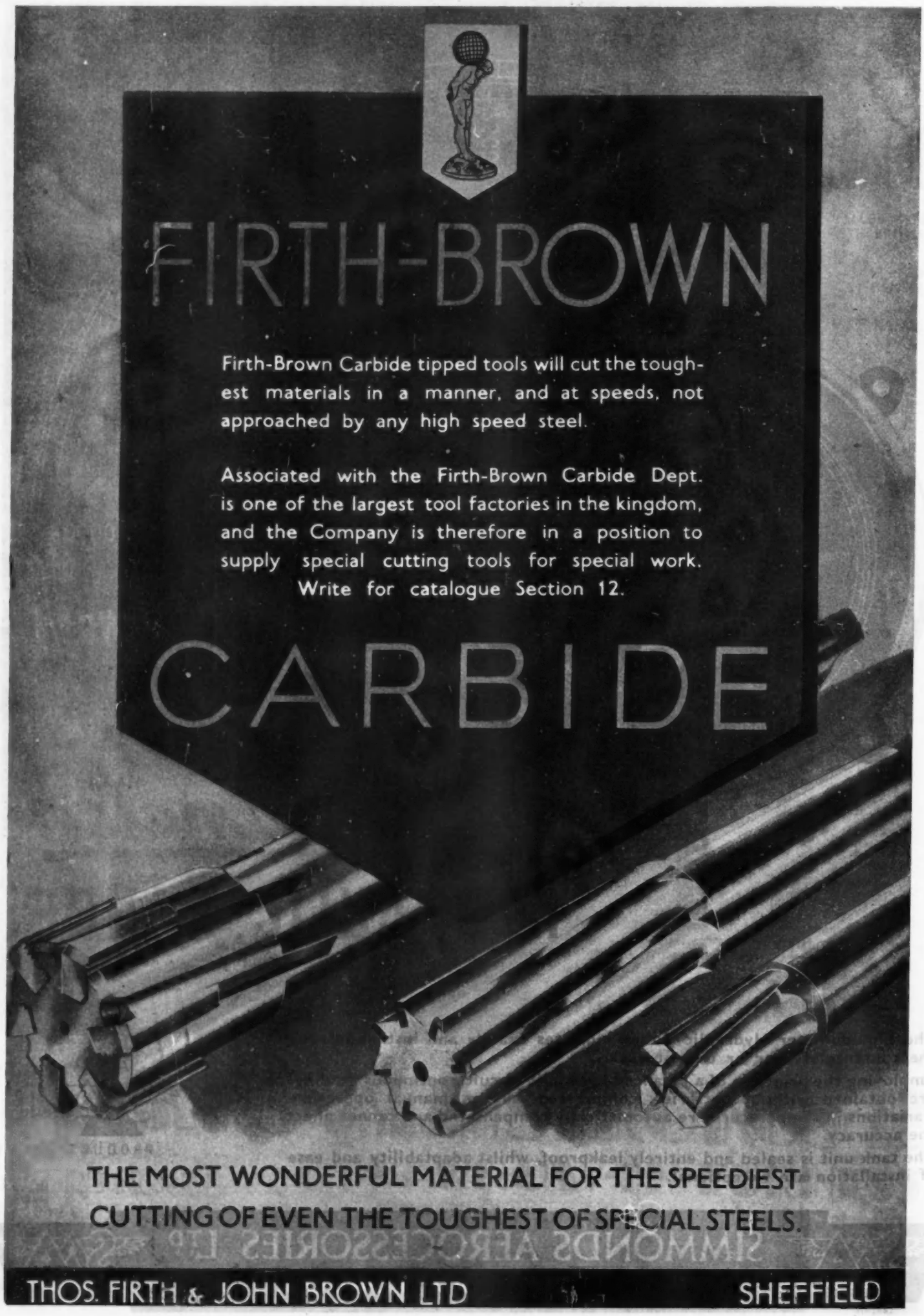
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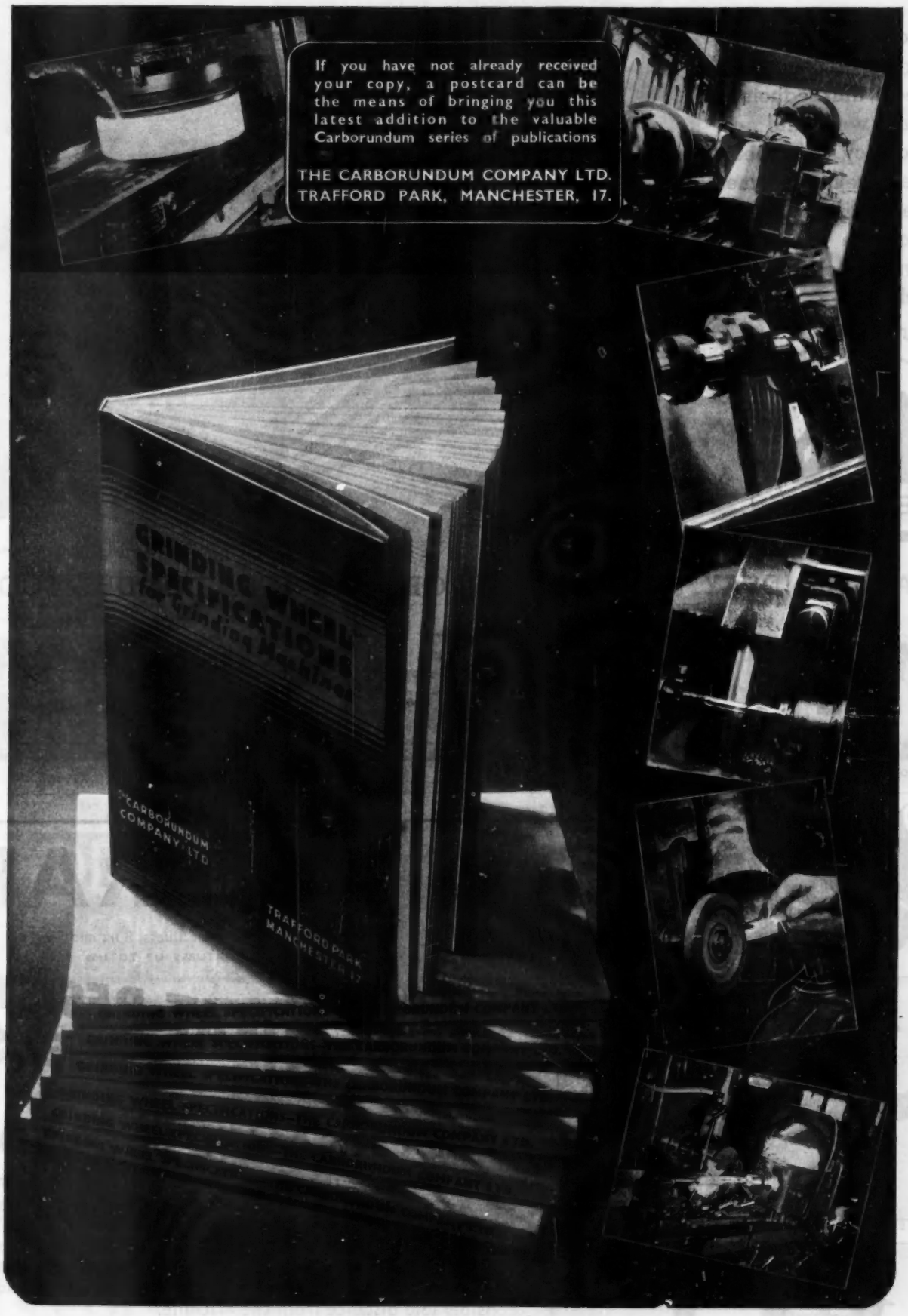
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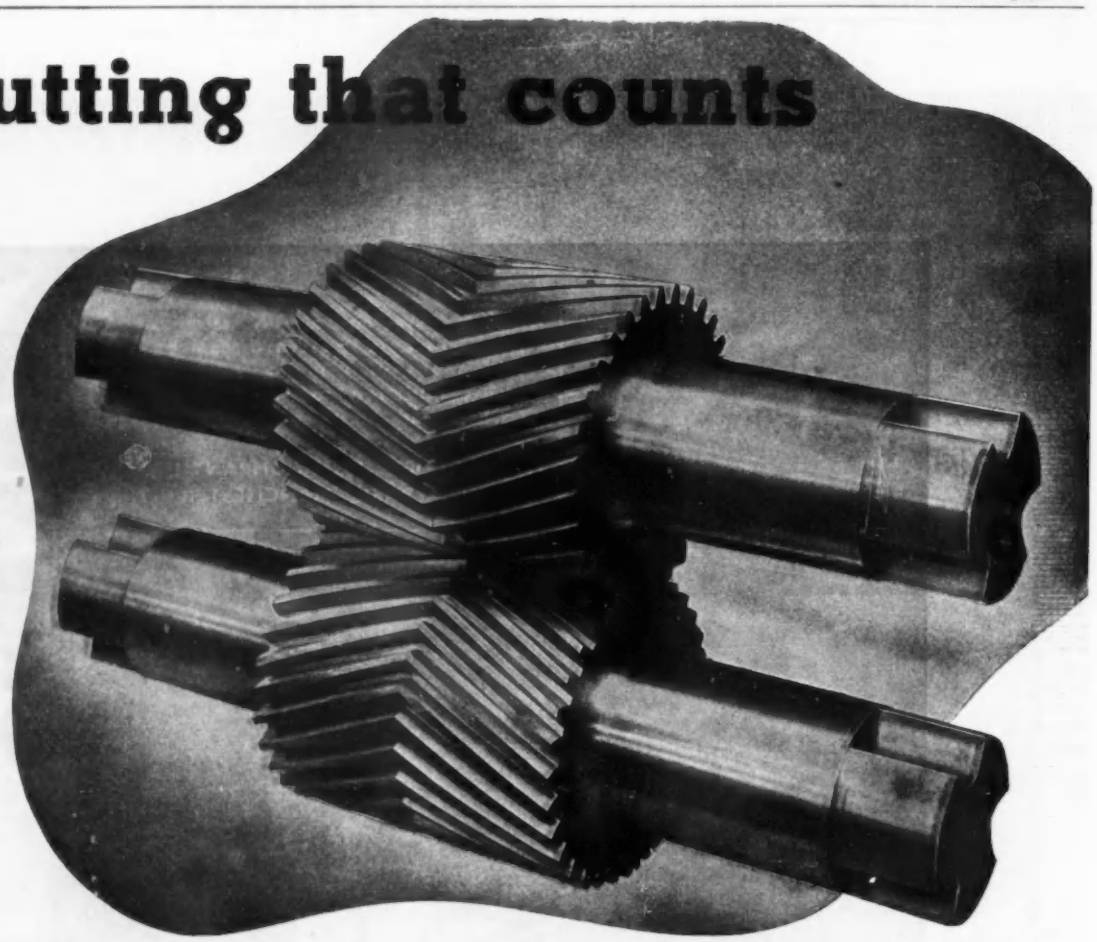

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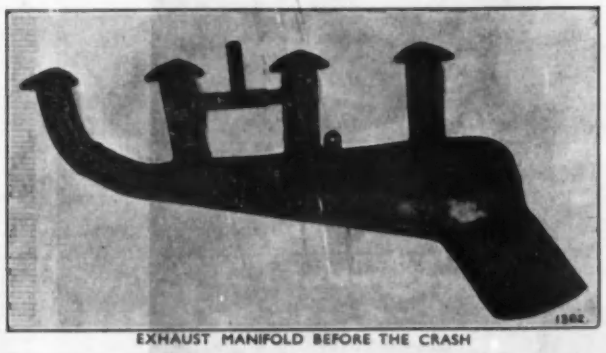

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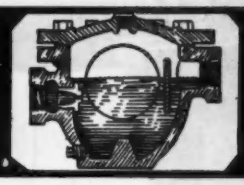

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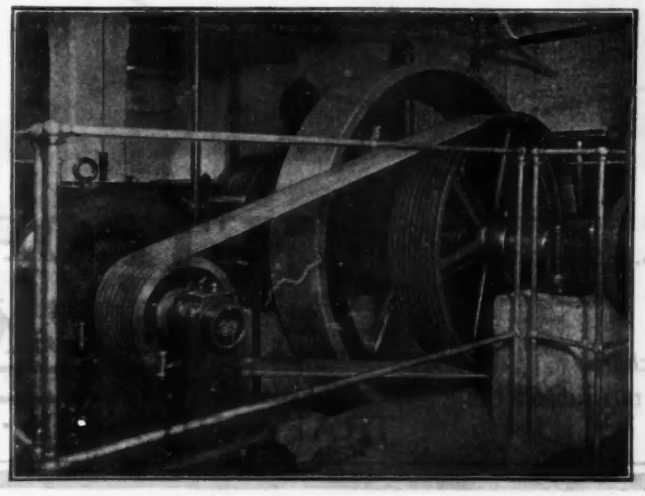

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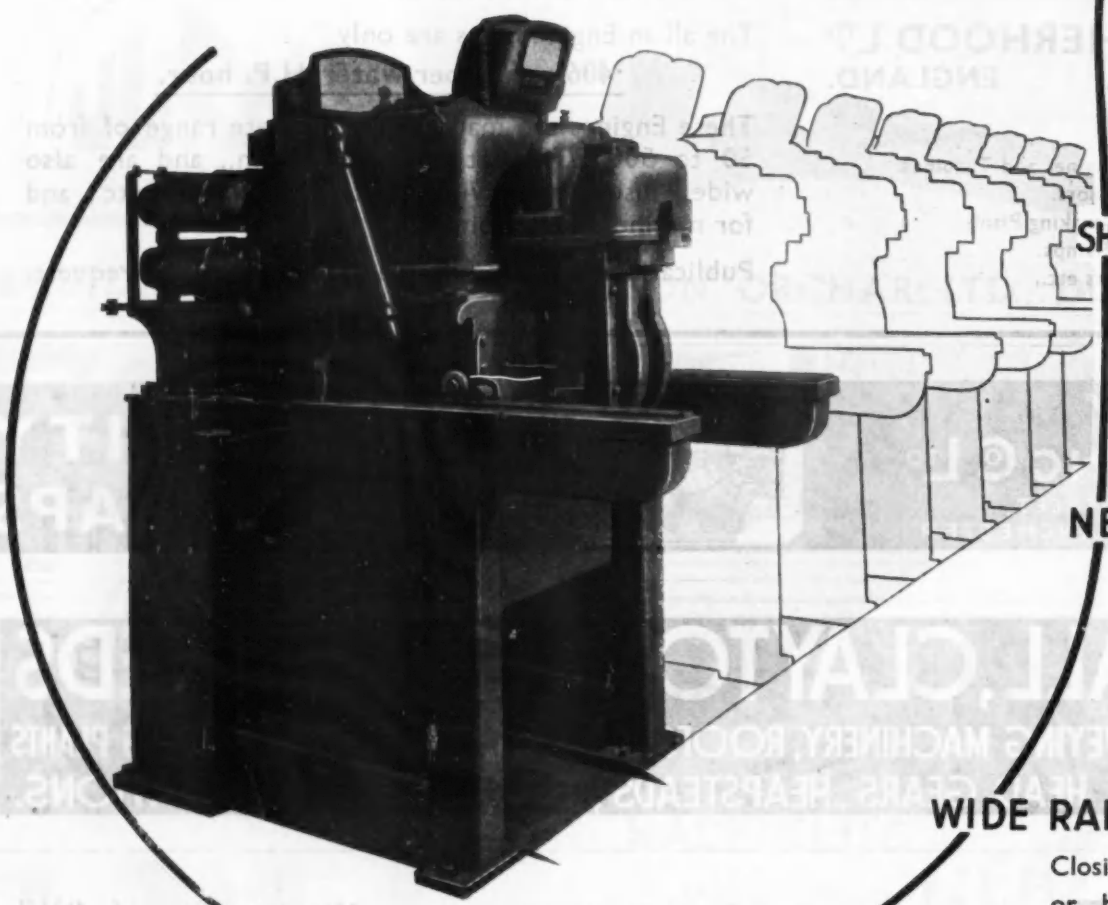

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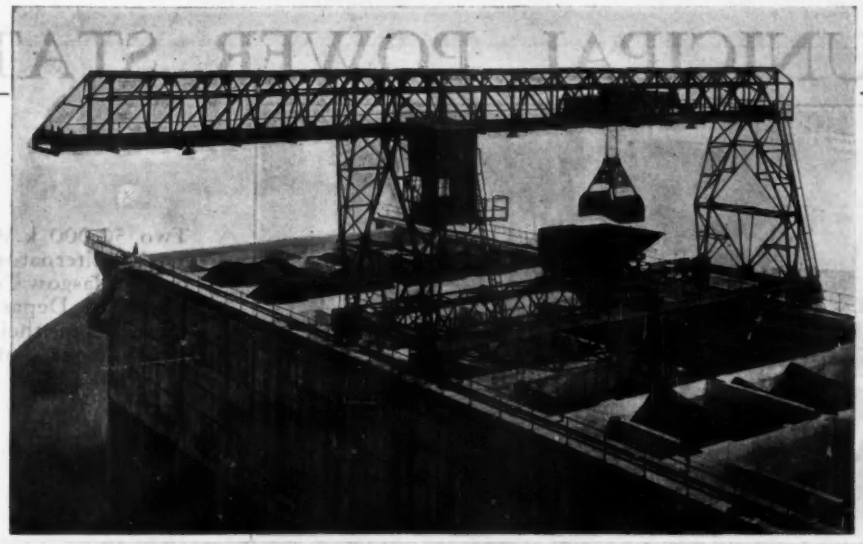

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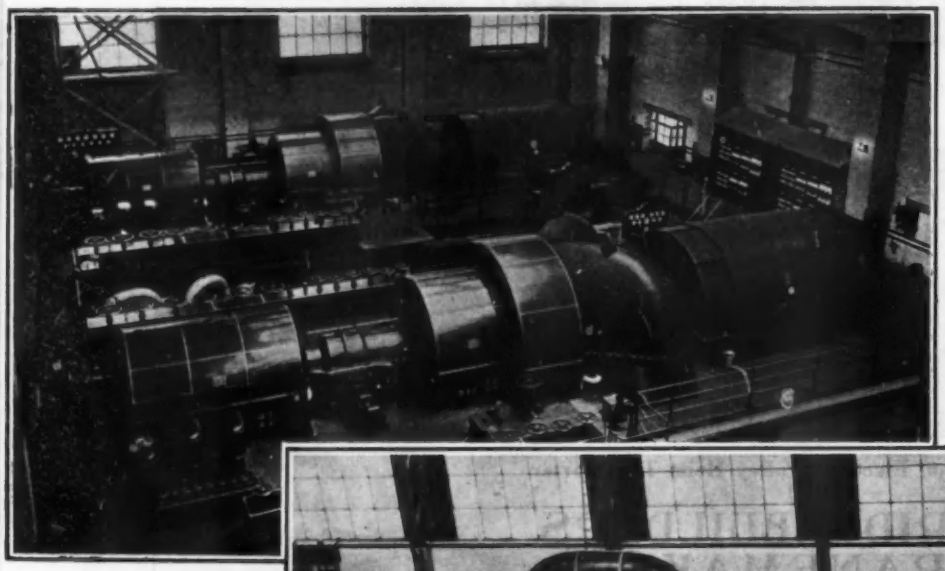

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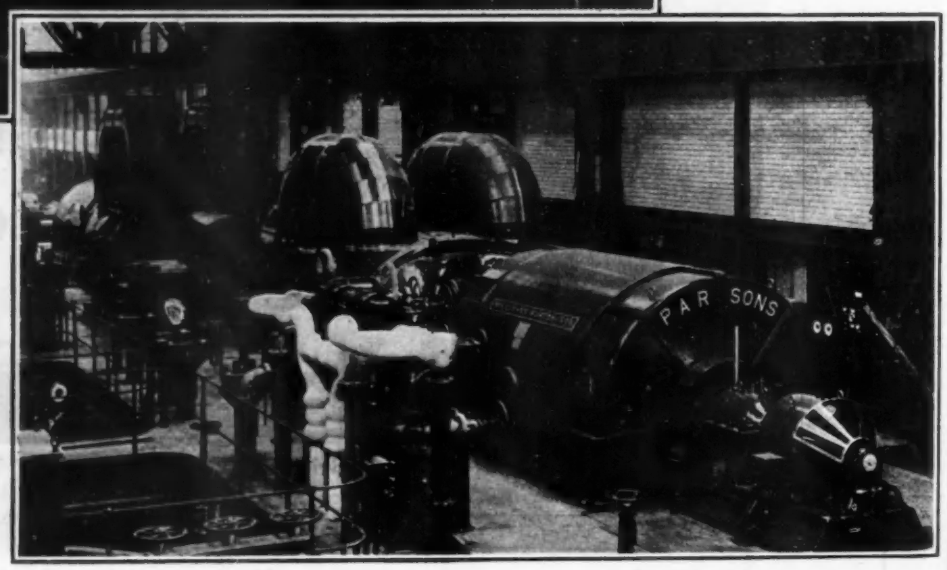

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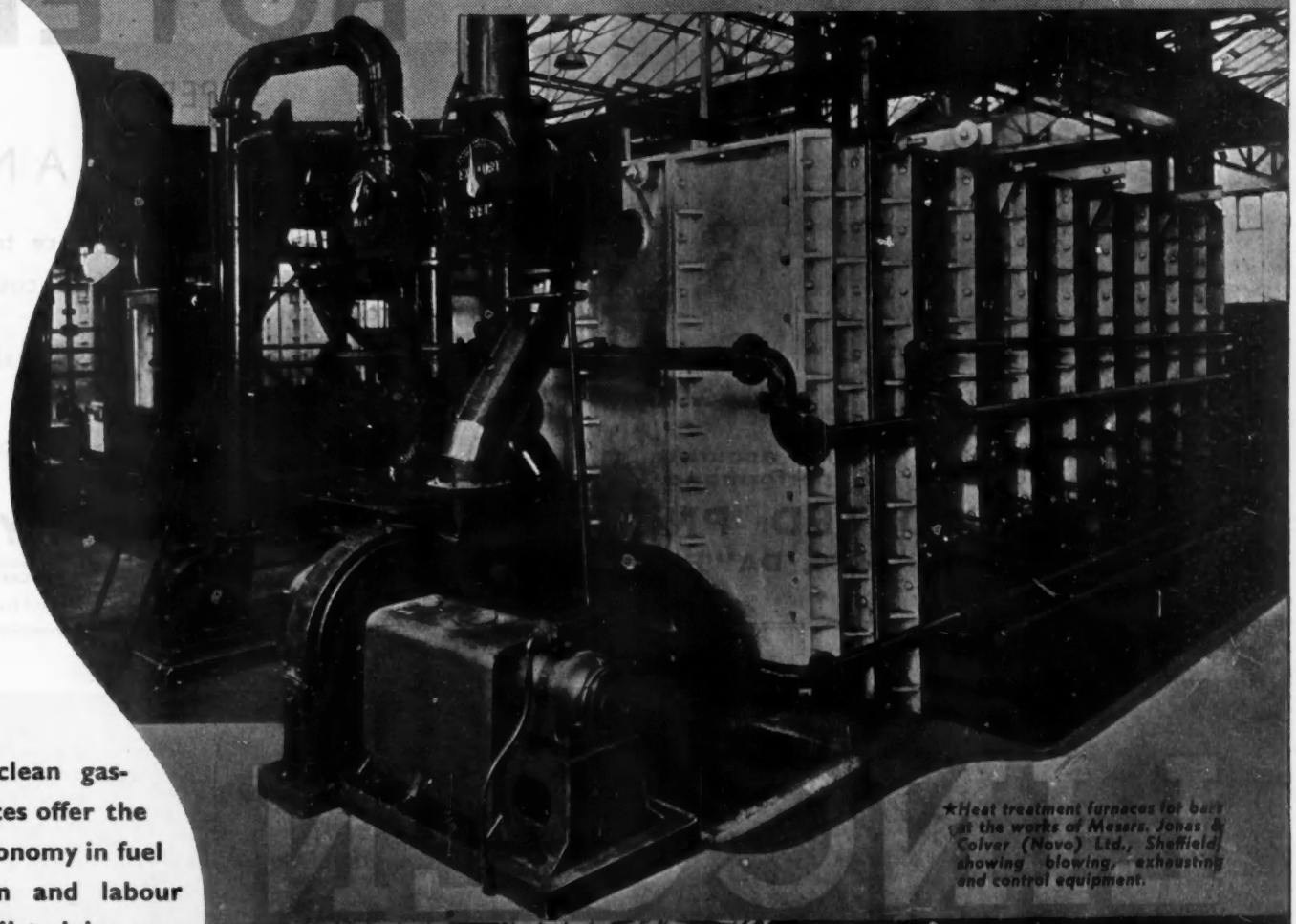

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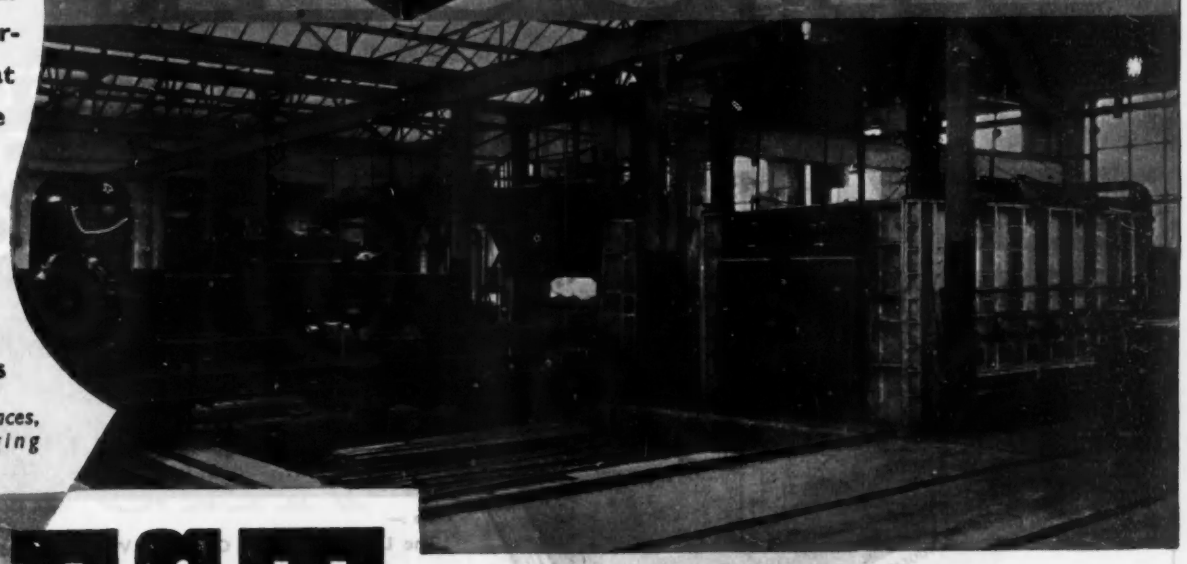

● *Front view of furnaces, showing charging machine.*

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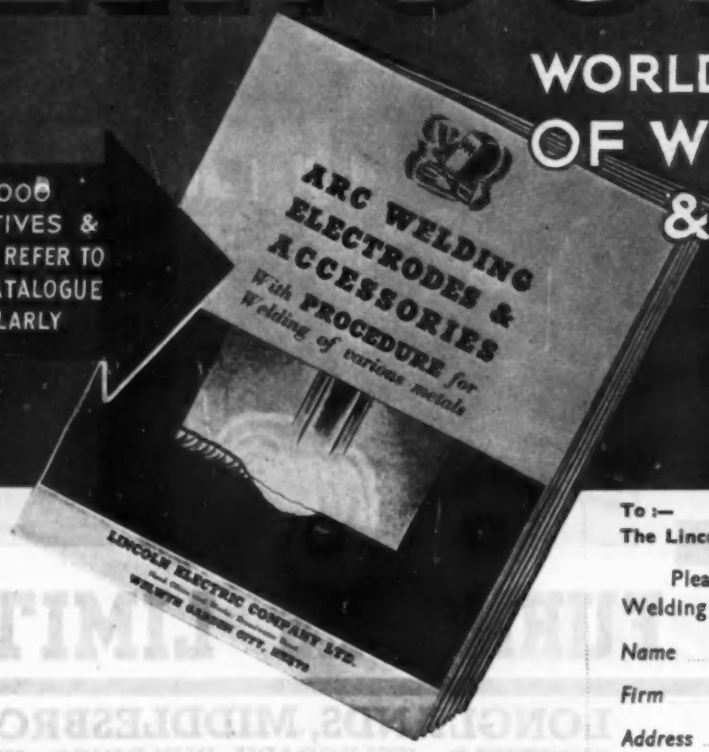

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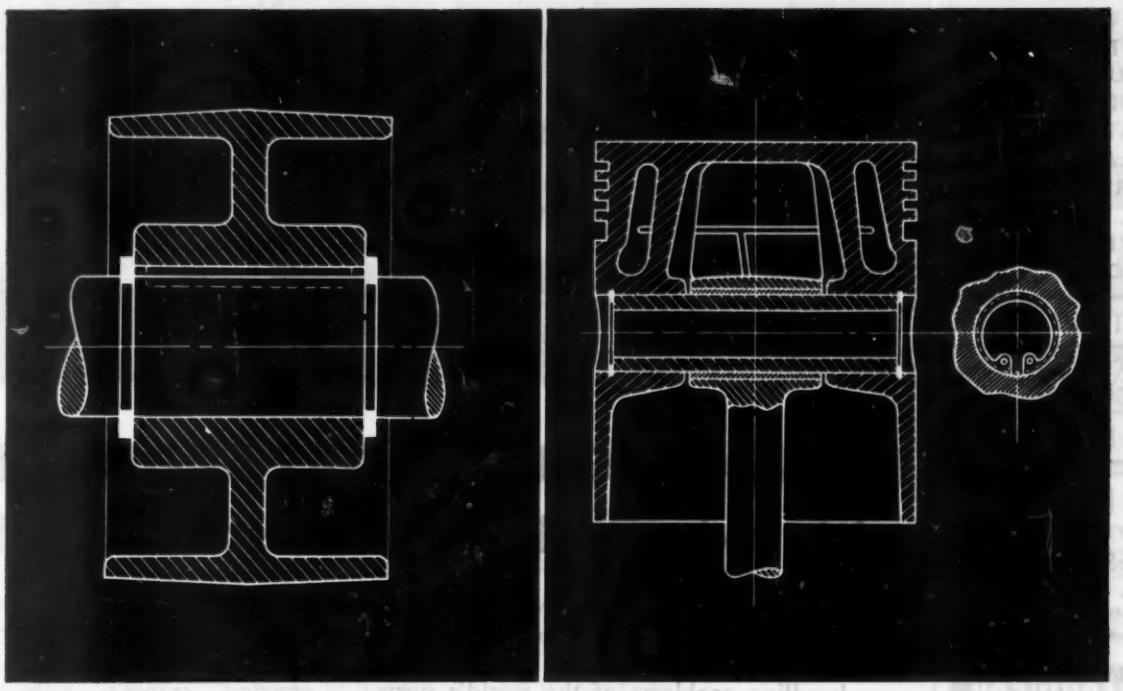

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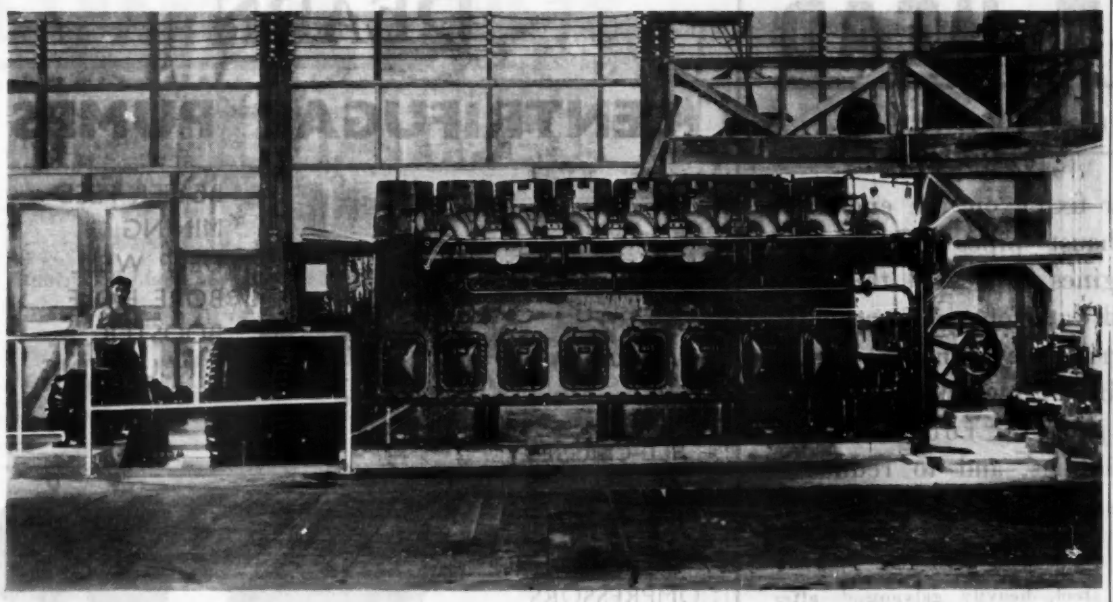

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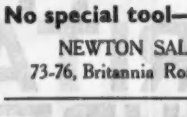

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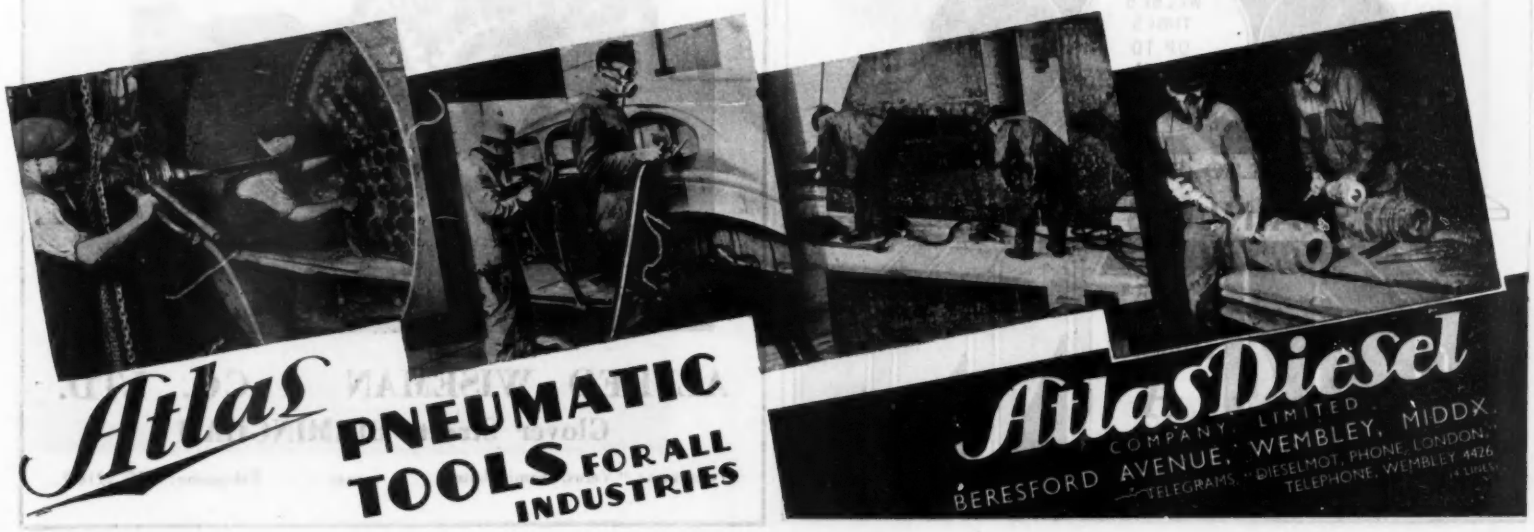

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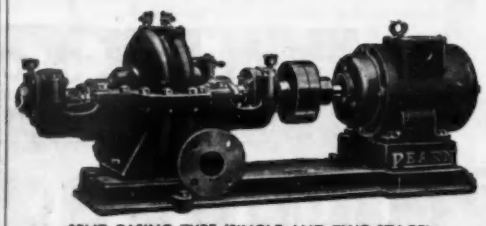

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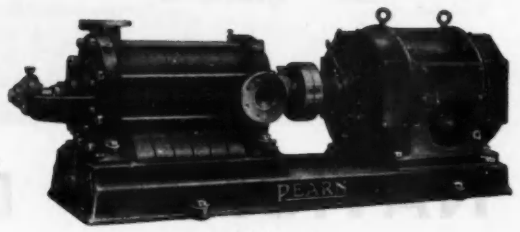

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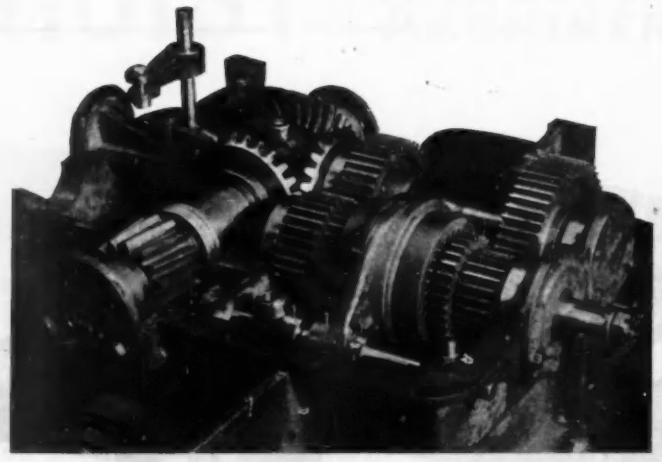

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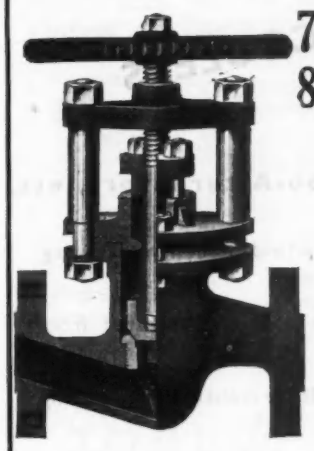

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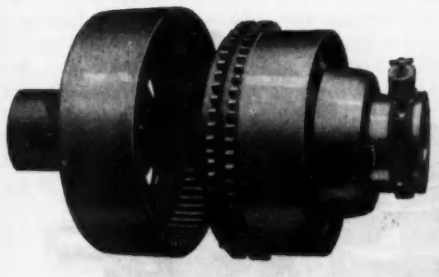

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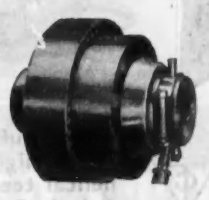

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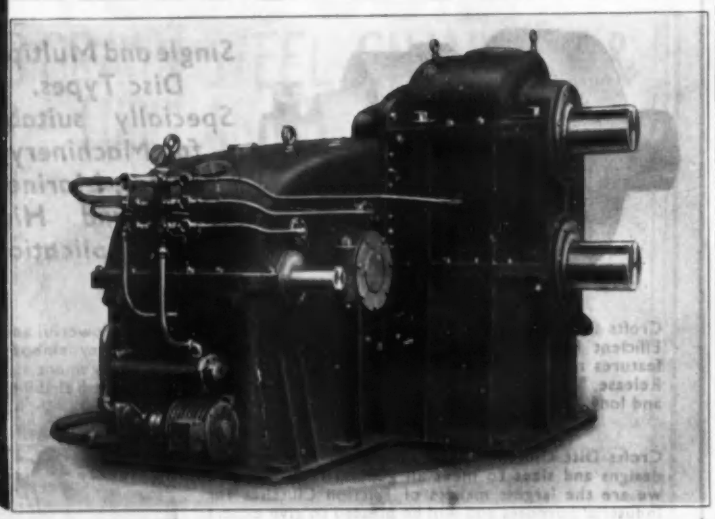

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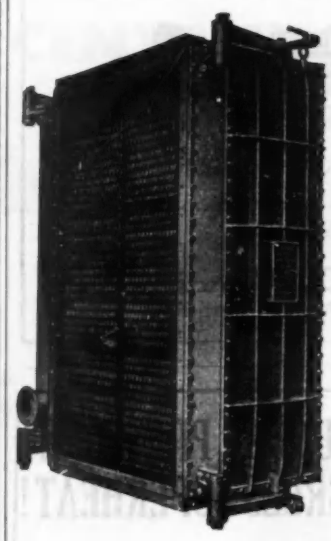

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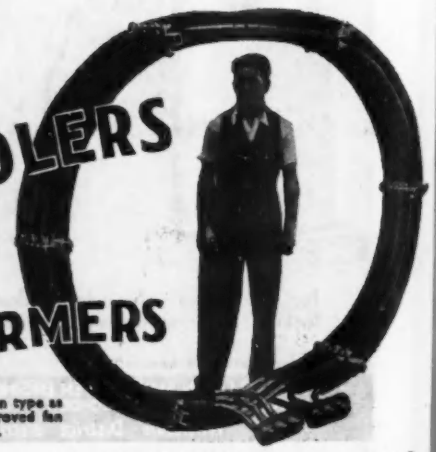

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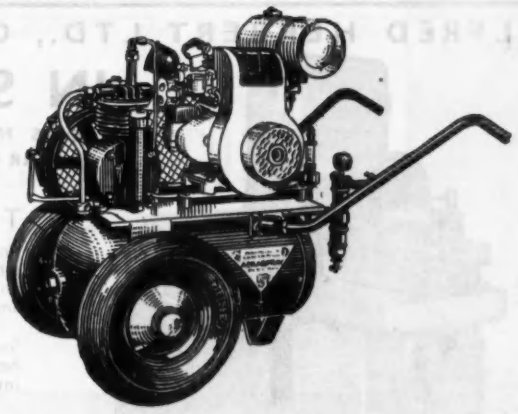

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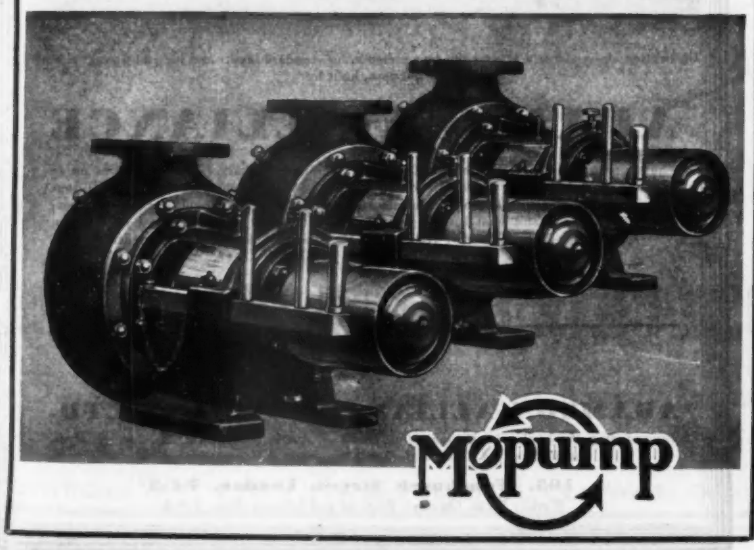

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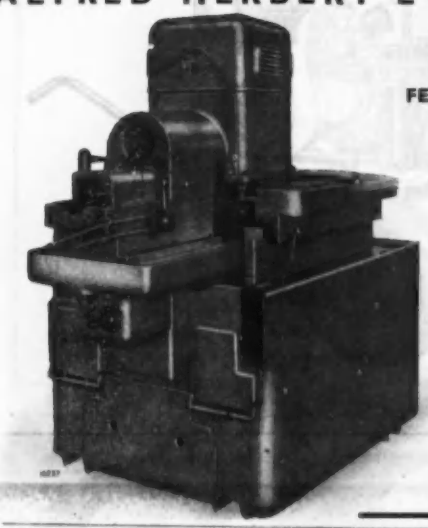

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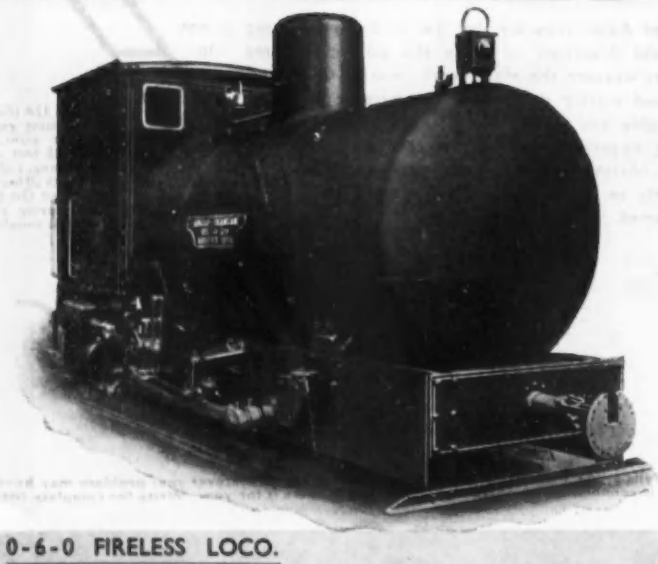

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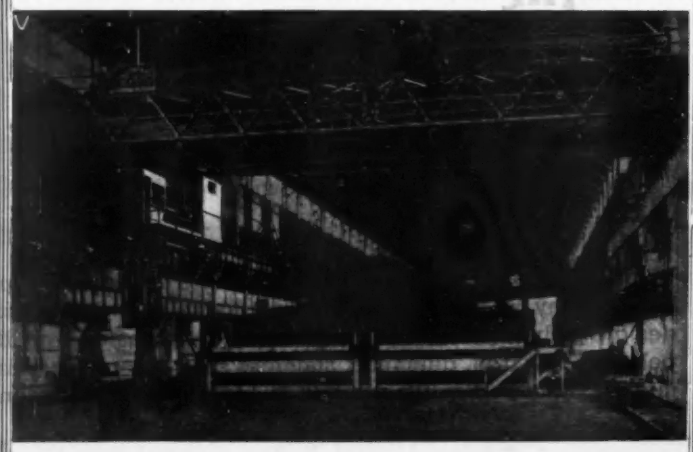

Illustration above shows a typical 200-tons Stripper, for standard ingots and big-end-up ingots with hot tops, built by

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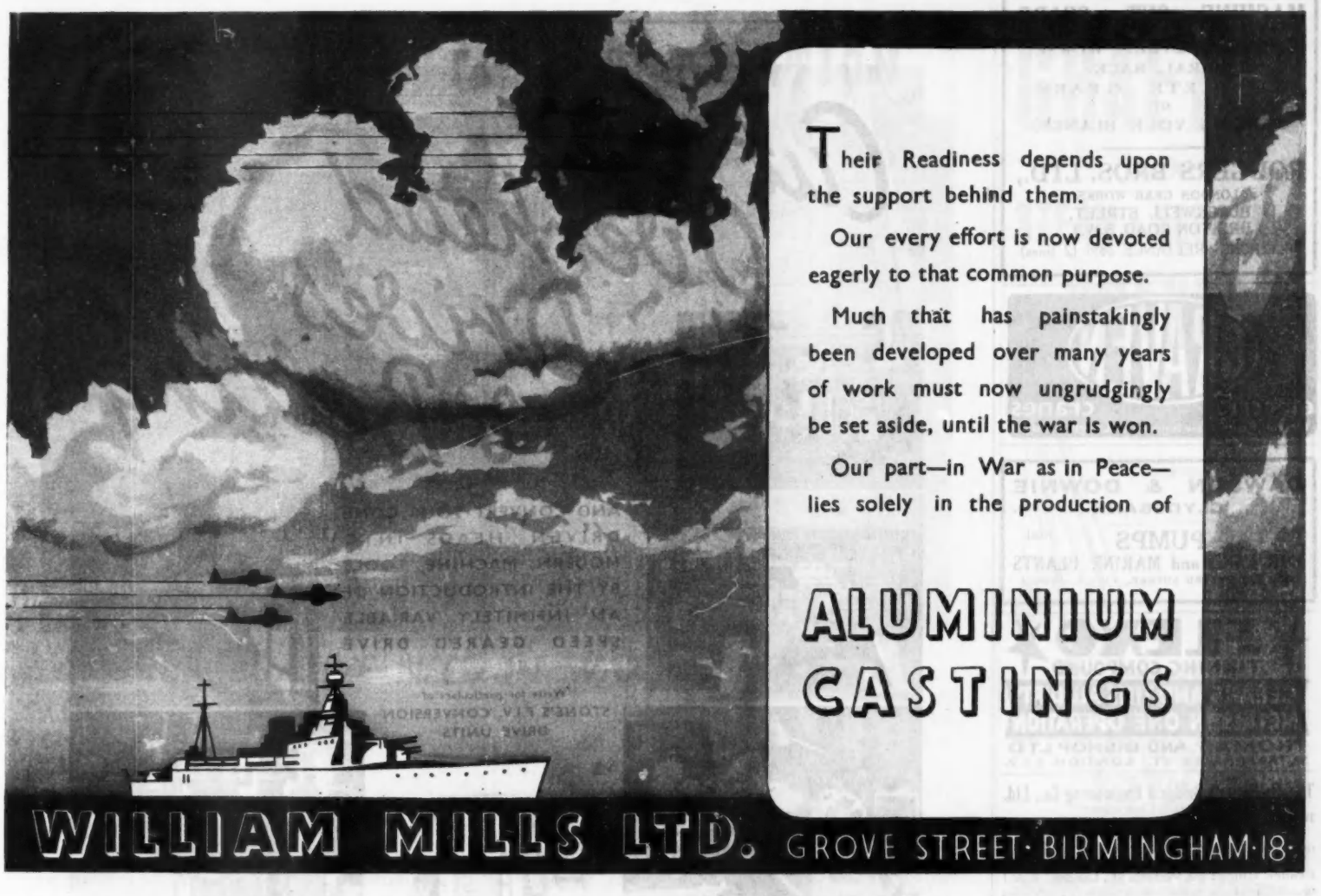
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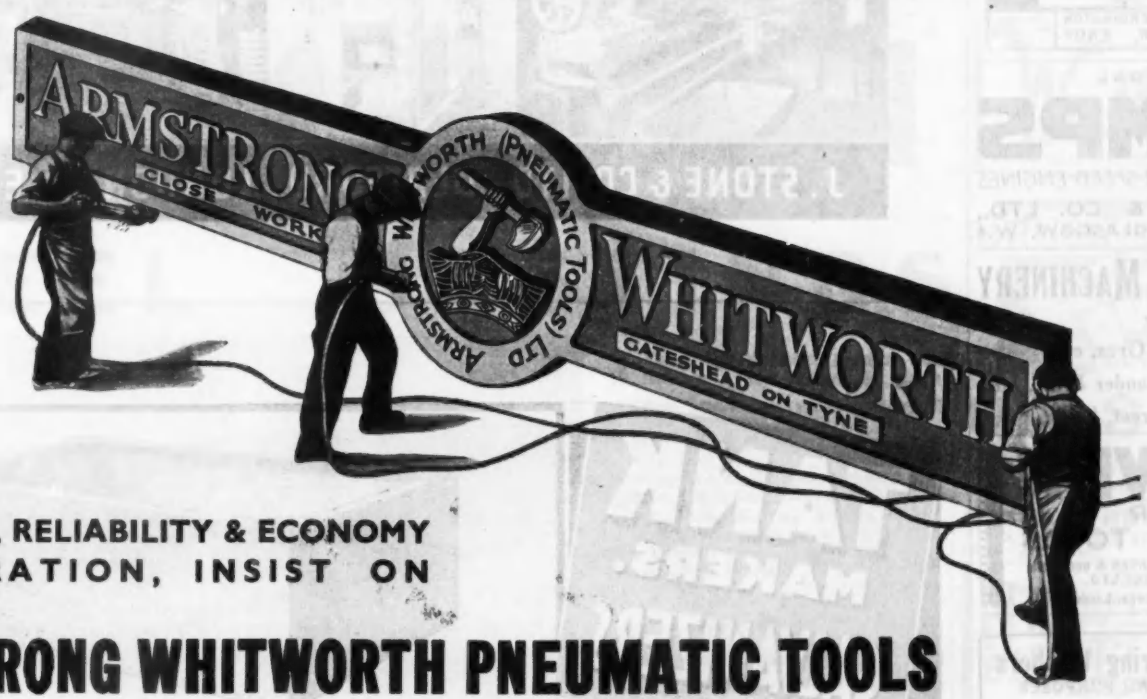

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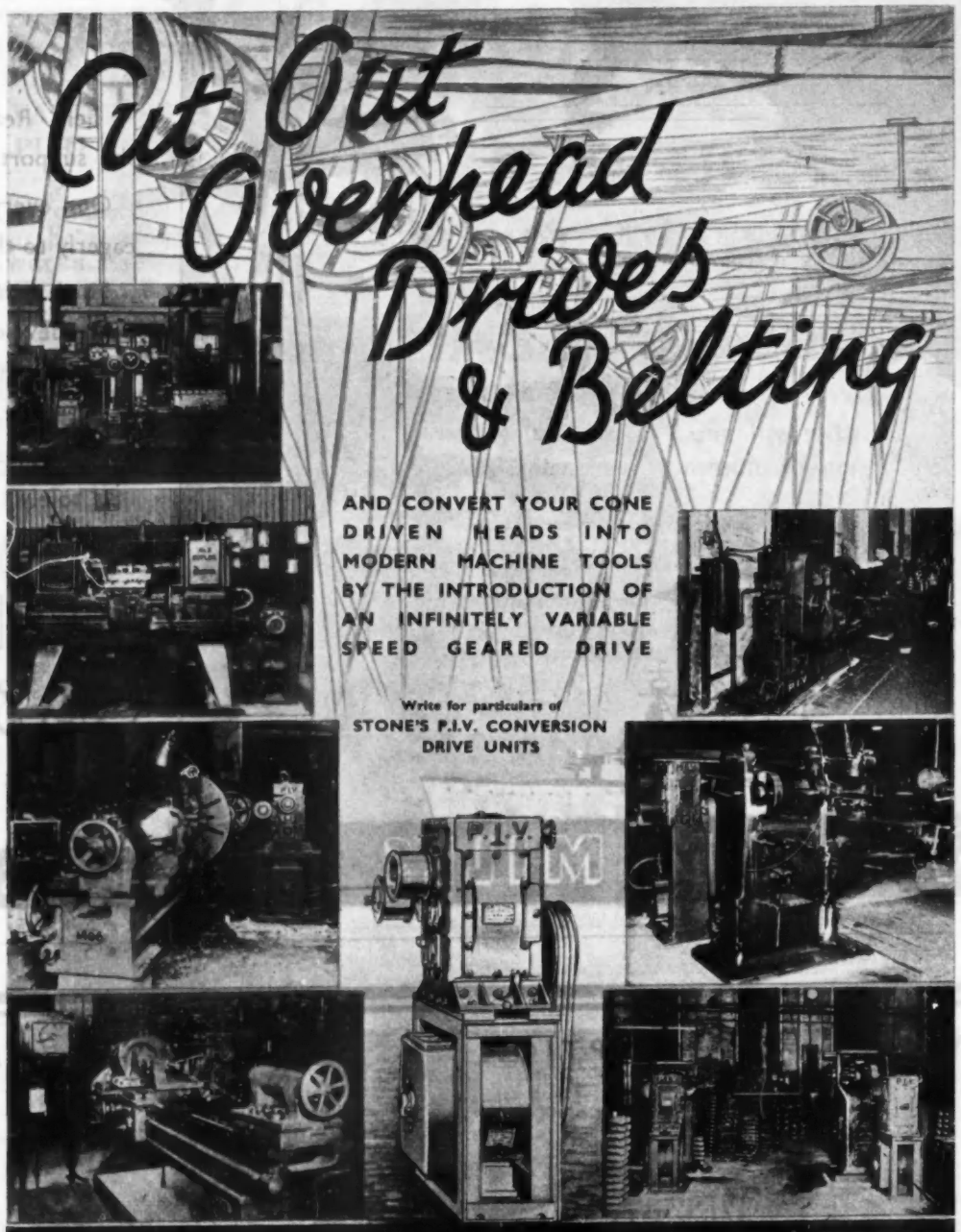

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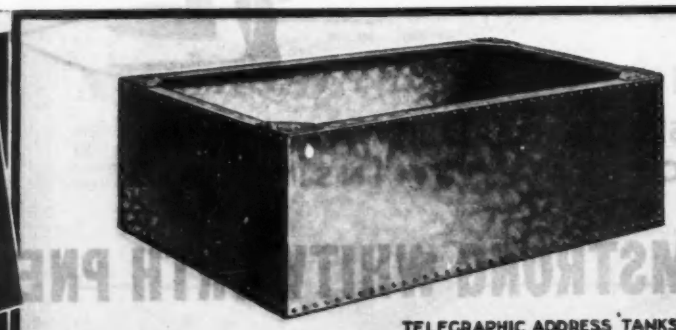
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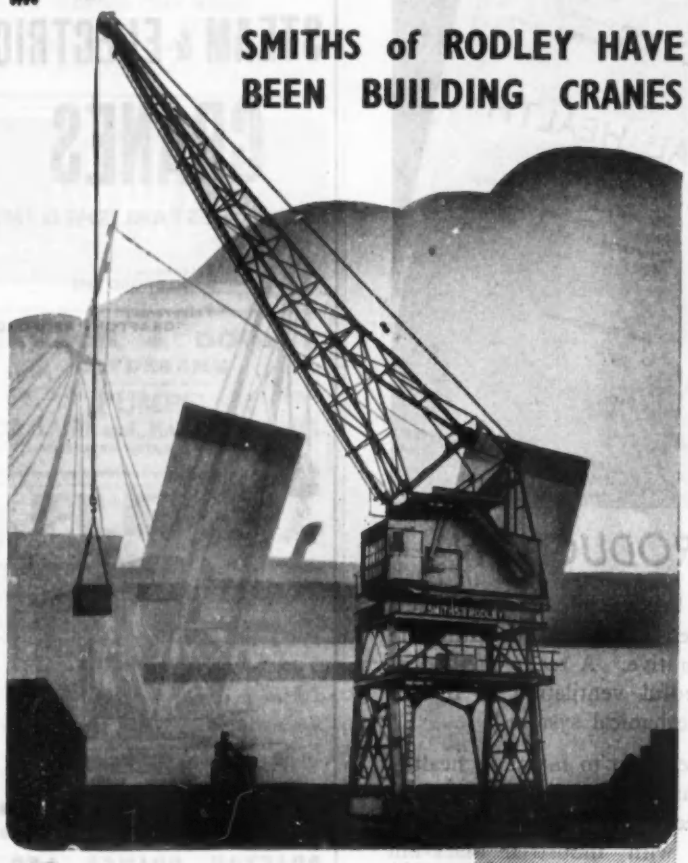

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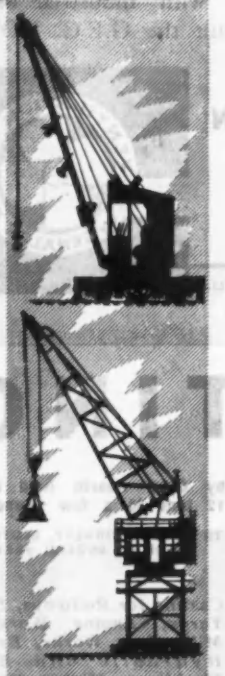

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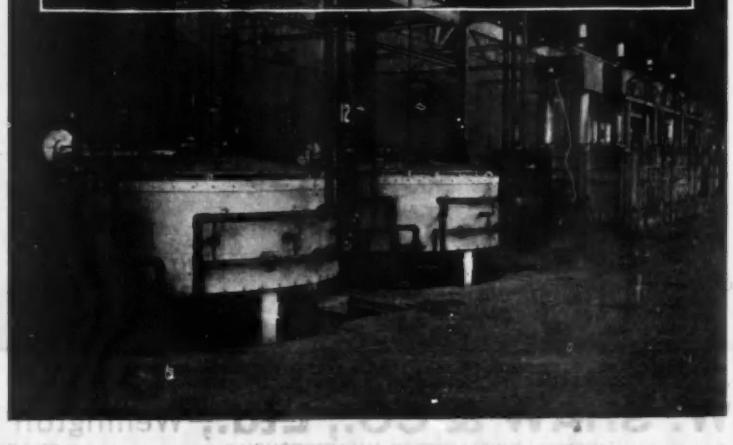

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Classified Advertisements continued from Page 8.

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See also Page 3.

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4-TON BUTLER LOCOMOTIVE STEAM CRANE; 4 ft. 8½ in. gauge; 35 ft. jib; lifting 4 tons at 15 ft.; wheelbase 7 ft. 6 in.; boiler 100 lb. w.p.
4-TON SMITH LOCOMOTIVE STEAM CRANE; 30 ft. jib; 4 ft. 8½ in. gauge; lifting 4 tons at 14 ft.; boiler 80 lb. w.p.
12-TON SMITH LOCOMOTIVE STEAM CRANE; 11 ft. gauge; fitted 35 ft. jib; lifting 12 tons at 17 ft. 6 in. radius; boiler 100 lb. w.p.
5-TON BROADBENT LOCOMOTIVE STEAM SHUNTING CRANE; 4 ft. 8½ in. gauge; fitted 35-ft. swan-neck jib, lifting at jib end and intermediately; boiler 80 lb. w.p.
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5-TON BUTTERS LOCOMOTIVE STEAM CRANE; 7 ft. 6 in. gauge; 32 ft. 6 in. jib; lifting 5 tons at 16 ft.; boiler 80 lb. w.p.
10-TON ELECTRIC DERRICK CRANE by BUTTERS BROS.; 80 ft. jib; all-steel construction; lifting 10 tons at 56 ft. down to 3 tons at 76 ft. radius; electrical equipment to suit A.C. supply; with audible indicator.
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6-TON HAND WHARF CRANE by THOMAS SMITH & SONS; 32 ft. channel jib; lifting 6 tons at 20 ft. radius.

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Telegrams: "Brecknell, Phone, Bristol."

COMPANY MEETINGS.

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SATISFACTORY CASH POSITION.
DISTRIBUTION OF 20 PER CENT.
INCREASED VOLUME OF WORK.
MR. A. M. NEAL'S ADDRESS.

The thirty-third ordinary general meeting of PETER BROTHERHOOD, LIMITED, was held yesterday at Winchester House, Old Broad Street, London, E.C.2.

Mr. ALEXANDER MARCUS NEAL, A.M.I.C.E. (Chairman of the Company), presided.

The Secretary (Mr. J. GERRARD), having read the Notice convening the meeting and the Report of the Auditors,

The Chairman said: Gentlemen, my first duty as Chairman is, I think, to refer to the recent death of one of our Directors, Mr. ALAN HUBERT CARNT, whose name appears on the Directors' Report, which is in your hands, but who has unfortunately died since this was printed, as a result of a motor accident on June 13th, while returning home from a business journey on behalf of the firm. All his colleagues on the Board, and all the other people who knew him, will miss his help and comradeship, and I would ask you, if you will, to stand for just one moment in respect to his memory.

The meeting then stood in silence.

THE CHAIRMAN: Thank you. I would like also to apologise for the absence of Mr. F. H. DAVIS, one of the Directors, who is remaining at the works in order that all the Directors should not be absent at the same time.

As the Directors' Report and Statement of Accounts have already been circulated, may I assume that you will agree to take them as read? (Agreed.) Thank you.

Now I should like, gentlemen, to make a few remarks on the Balance Sheet and Accounts which have been circulated. If you will kindly refer to the Balance Sheet—on the Assets side, the first item, Cash at bank and in hand, stands at £127,674 (quoting to the nearest pound), and shows an increase of £8,389 on last year's figure. In view of the expansion of our business during the year and the large payments we have necessarily had to make for materials for contracts now in hand, I think you will agree that the cash position at the 31st March was quite satisfactory. The next item, Sundry Debtors, shows an increase of £10,450, whilst stock in hand and work in progress—the next item—stands at £498,284, against £344,445 last year. Both of these increases are, of course, attributable to the considerably increased amount of work carried out during the year and at present in hand.

PLANT FULLY UP-TO-DATE.

Fixed Plant and Machinery stands at much the same figure, namely, some £137,000, indicating that the purchase of new machine tools during the year amounting to £21,011, is, to a great extent, offset by the normal depreciation for the year of £10,361, plus the special depreciation of £10,000, which you were good enough to confirm at our meeting last year. I need hardly emphasise that this question of machine tools is one which is constantly in the minds of your Directors, and that increased output has demanded, and will continue to demand, considerable expenditure in plant and machinery. Your Directors are satisfied that at the moment the plant is fully up-to-date and capable of dealing with any demands which may be made upon it.

The other items on the Assets side do not call for special comment, with the exception, perhaps, of the last item, Air Raid Precautions Suspense Account, at £12,275. Towards this, you are to-day, as you will note from the Directors' Report, asked to agree to set aside the sum of £7,500, as last year, which, with the £5,000 we expect to recover from the Government, will liquidate this item from the Balance Sheet.

INCREASED TAXATION.

On the Liabilities side of the Balance Sheet the increase in sundry creditors of £34,175 reflects again the increased amount of work being carried out, but provision for taxation at £70,730 against £23,228 last year is a reminder of the extent to which it is the duty of us all to place our strength and substance at the service of the Government.

The next item, General Reserve, remains at £50,000, but, as you will see from the Directors' Report, we propose to ask you to sanction the setting aside of £10,000 as last year for special depreciation of machine tools and machinery generally.

PROFIT AND DIVIDEND.

Turning to the Profit and Loss Account, the net profit for the year, before providing for Income Tax and Excess Profits Tax, is £139,050, against a figure last year of £98,174, but the Income Tax and Excess Profits Tax reduce the amount of profit made during the year and available for distribution and other purposes to £75,550, against £81,924 last year. In view of the prevailing conditions of uncertainty, of the necessity to conserve the Company's resources and of the impending increase in the rate of Excess Profits Tax from 60 per cent. to 100 per cent., your Board, after careful consideration and after taking the advice of their financial adviser, Mr. C. J. G. Palmour, who we have very much pleasure in having with us this morning, has unanimously decided to recommend the payment of a final dividend of 12 per cent. on the Ordinary Shares, making, with the 8 per cent. interim dividend already paid, a total dividend for the year of 20 per cent. on the Ordinary Shares, against a total of 24 per cent. last year. It is interesting to note that this rate of 20 per cent. on the nominal ordinary share capital represents only some 9·2 per cent. on the actual capital, other than Preference capital, employed in the business.

THE FUTURE.

That, I think is about the end of the remarks which can reasonably be made on the Balance Sheet, and it is usual here, I think, to say something about the future. Well, under the existing circumstances this is a little difficult; we are really more concerned with the immediate present. The ratio of commercial to Government work has, of course, been to a great extent, and is likely to be still further, upset. We are taking our instructions from the Authorities who alone are in a position to know in what direction we can be most useful. Every person connected with the firm has been working and will continue to work to his or her utmost capacity. This is only to be expected of us in the present state of affairs, which I am sure you will agree we all trust and hope will be of as short a duration as is reasonably and justifiably possible.

The report and accounts were unanimously adopted and the dividend recommendation approved.

The retiring directors, Mr. J. H. KEMP-WELCH, M.B.E., and Engr. Rear-Admiral F. G. HADDY, M.V.O., were re-elected; the Auditors, Messrs. WHINNEY, SMITH & WHINNEY, were re-appointed.

The proceedings terminated with a hearty vote of thanks to the Chairman, Directors and Staff.

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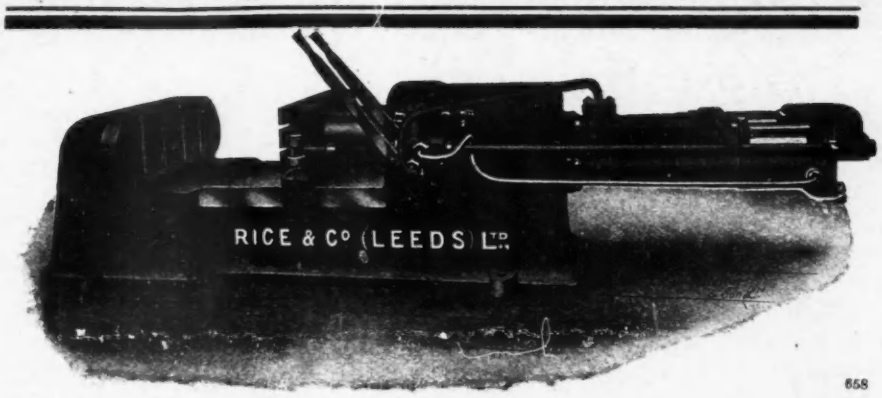

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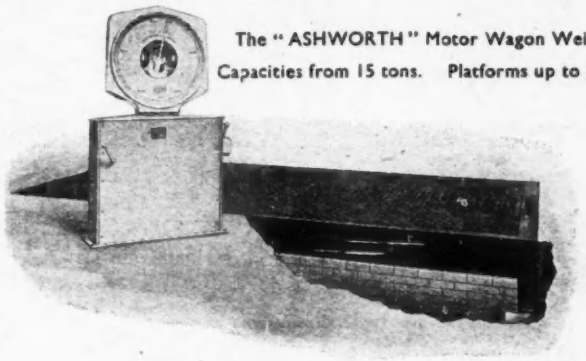

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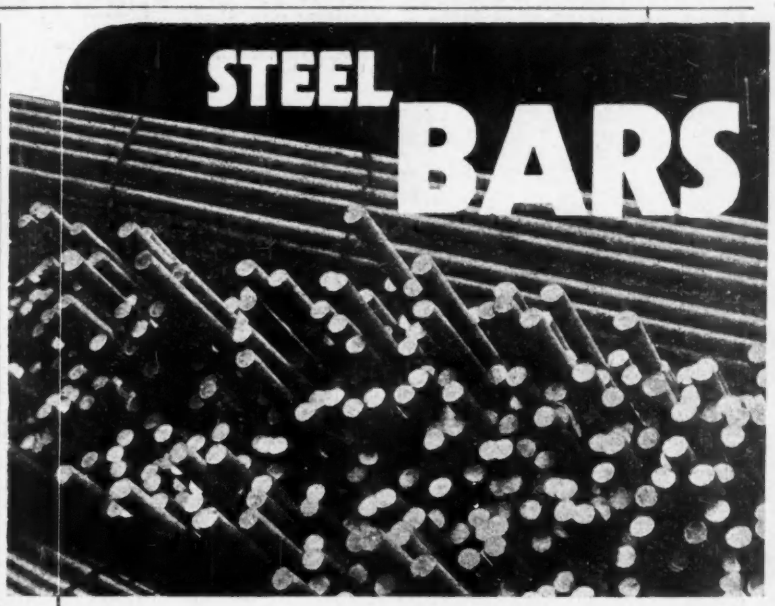

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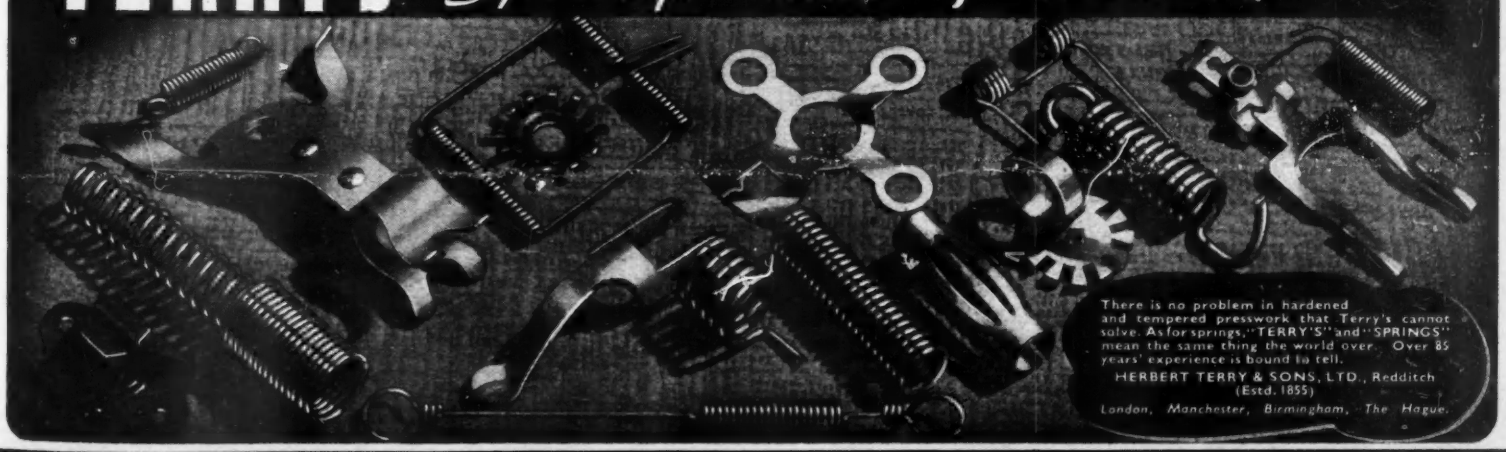

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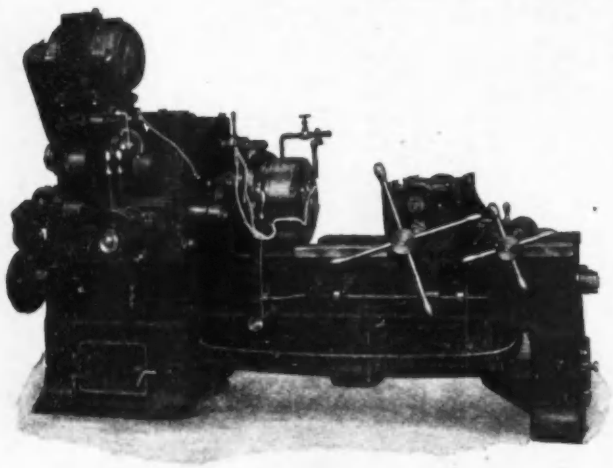

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